FRED Reports

PAINT RIVER FISH PASS
FEASIBILITY STUDIES
1978-1983

by
Alan Quimby and
Nick Dudiak

Number 72

Alaska Department of Fish & Game
Division of Fisheries Rehabilitation,
Enhancement and Development

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ABSTRACT

The Paint River system, located in the Kamishak Bay area, has 40 km (25 miles) of ideal spawning habitat in its main stream, headwater lakes, and tributaries. A steep set of falls located at the mouth of the river prevents the development of salmon runs in this system. A smaller set of falls at the outlet of Lower Paint Lake also prevents salmon from entering the lake systems. We estimate that spawning and rearing habitat in this system could support the following magnitudes for three species of Pacific salmon: 100,000 adult sockeye salmon, *Oncorhynchus nerka*; 900,000 adult pink salmon, *O. gorbuscha*; and 600,000 adult chum salmon, *O. keta*, annually. Work to date has been done cooperatively with the Cook Inlet Aquaculture Association.

Baseline physical, limnological, and biological data were obtained from the lakes and river systems by plankton and water-quality sampling, test fisheries, and other quantitative surveys. Overall average zooplankton density for Upper Paint Lake was 2,800 organisms/m^3, with the highest at 4,750 organisms/m^3. Dominant species were cyclopoid copepods and cladocerans. Overall average density for Lower Paint Lake was 362 organisms/m^3, with the highest density at 830 organisms/m^3.

Grayling, *Thymallus arcticus*; round whitefish, *Prosopium cylindraceum*; and lake trout, *Salvelinus namaycush*, currently inhabit the lake systems, suggesting that predation would be a factor in salmon-enhancement work for this system. Some rainbow trout, *Salmo gairdneri*, were found in the mainstream and tributaries of the Paint River.

Pink salmon fry from Tutka Lagoon Hatchery were stocked for four consecutive years in the lower reaches of the mainstream of Paint River. The first fry transport, in 1980, was 554,000 fry; of those, approximately 30,000 were marked with an AdLV (excised adipose and left-ventral fins) finclip. In 1981, 509,000 fry

were transported to the river; 30,700 were marked with an AdLV. In 1982, 405,000 unmarked fry were transported to the river. The last transport occurred in 1983, with the release of 502,000 unmarked fry.

The first adult pink salmon returned to the river in 1981; between 25 and 600 fish were observed by aerial survey, yielding an estimated return of only 0.1%. In 1982, 4,700 adult pink salmon were observed returning to the area of the Paint River, yielding an estimated 0.9% marine survival. No fish were observed returning in 1983.

Preliminary engineering studies indicate that the intertidal falls migrational barrier can be bypassed by construction of a fishpass. At least four different engineering options are available. In addition, the minor set of falls below the lake system can also be overcome by means of a bypass channel.

KEY WORDS: Paint River, Kamishak Bay, fish pass selection, pink salmon, *Oncorhynchus gorbuscha*, survival rates, aerial fish transports.

INTRODUCTION

The Paint River includes a large network of streams with interspersed lake systems located near the Kamishak Bay area. Preliminary site reconnaissance revealed at least 40 km (25 miles) of potential salmonid spawning and rearing habitat. There is a steep set of falls located at the mouth of the river in Akjemguiga Cove (Figure 1) that has prevented the development of salmon runs to this system. Records indicate that there has never been salmon production in the Paint River system.

In a cooperative program, the Fisheries Rehabilitation, Enhancement and Development (FRED) Division and Cook Inlet Aquaculture Association (CIAA) initiated studies to assess the engineering and biological feasibility of construction and operation of a steeppass fishway at the intertidal falls area. Biological surveys have been conducted periodically since 1978. An intensive engineering survey was conducted during 1981. By providing salmonid passage through this migrational barrier, the entire Paint River system would be open and available as potential spawning and rearing habitat. This system could probably support all five species of Pacific salmon to varying escapement rates, but potentials for the system are estimated at 100,000 adult sockeye salmon, *Oncorhynchus nerka*; 900,000 adult pink salmon, *O. gorbuscha*; and 600,000 adult chum salmon, *O. keta*, annually.

Study Area

The Paint River is located on the east side of the Alaska Peninsula in Kamishak Bay, lower Cook Inlet (Figure 1). From a high mountain valley, the river flows 15 km in an easterly direction into salt water at Akjemguiga Cove. Lake Fork River, Kenty Creek, Sulukpuk Creek, and Dunuletak Creek constitute the four major tributaries emptying into the Paint River (Figure 2). The Lake Fork tributary headwaters include three interconnecting lakes: Lower Paint, Upper Paint, and Elusivak lakes (Figure 2).

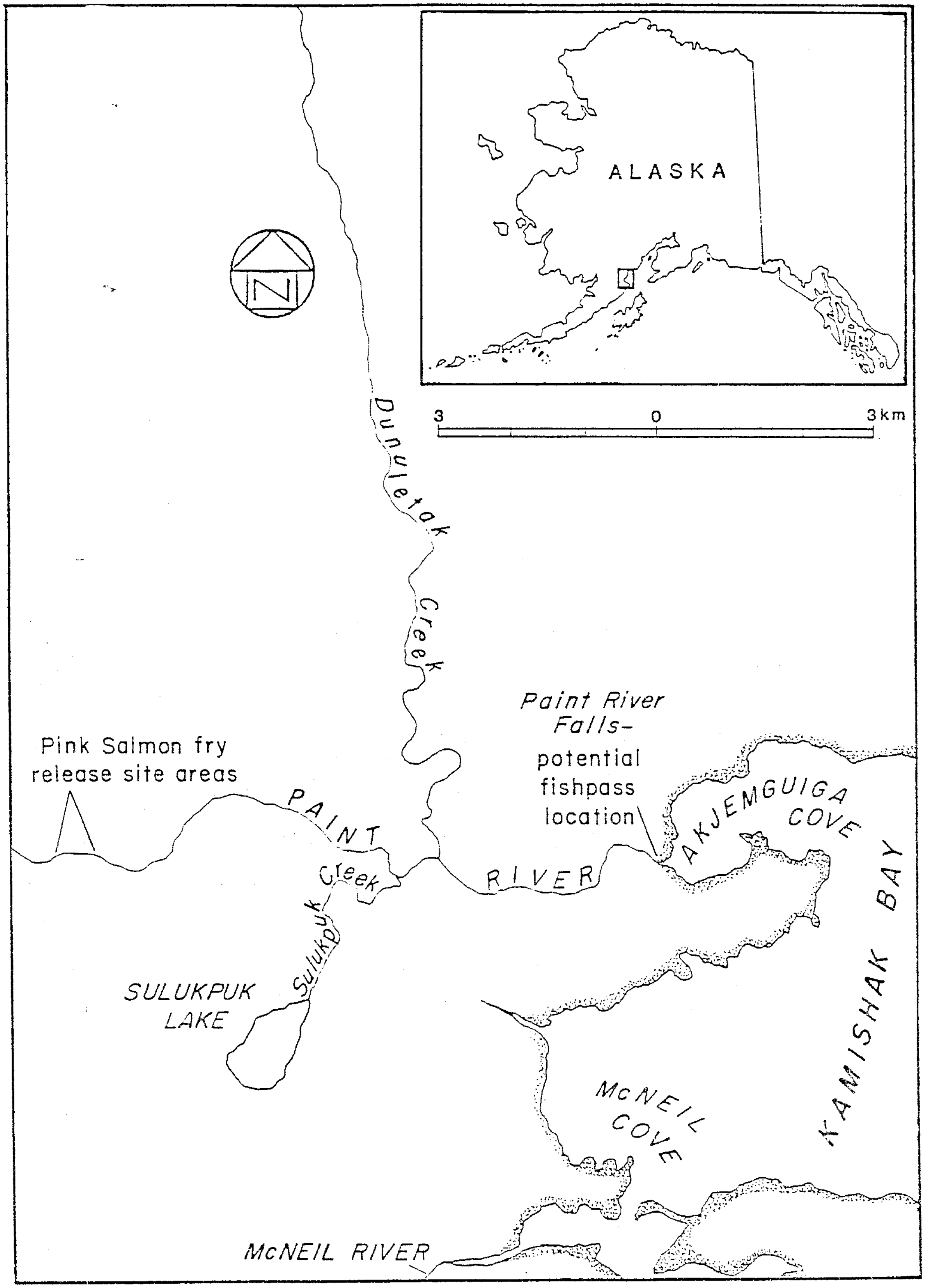

Figure 1. Paint River and tributaries, Kamishak Bay, Alaska.

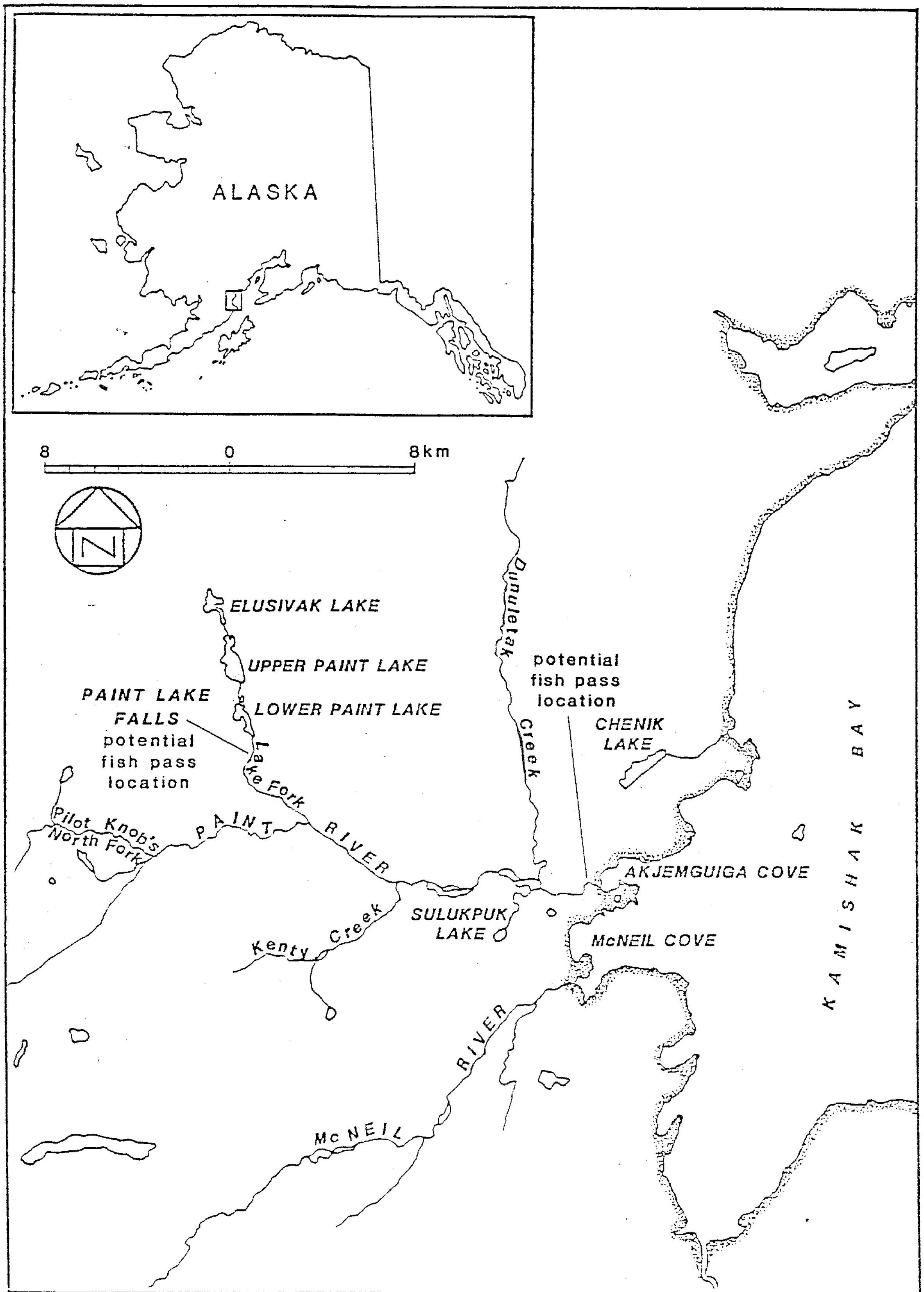

Figure 2. Paint River and Paint Lakes Falls, Kamishak Bay, Alaska.

Sulukpuk Lake is one other major lake that drains into the lower reaches of the Paint River (Figures 1 and 2).

There are two major migrational fish barriers located in the Paint River system. Paint River Falls is the larger of the two and is located at the river mouth (Figure 1). There is a vertical drop of approximately 12 m directly into salt water at Akjemguiga Cove during a 0.0 m tide. The height of the falls varies accordingly with the height of the tides. The second barrier, Paint Lakes Falls, is located approximately 150 m downstream from the outlet of Lower Paint Lake (Figure 2). Paint Lakes Falls drops about 6 m vertically into a large pool.

MATERIALS AND METHODS

Aerial Surveys

Because of the topographical features and remoteness of the Kamishak Bay area, Bell 206 Jet Ranger helicopters proved to be the most practical means of providing logistical support for the survey of the Paint River system. Helicopters were able to fly slowly and close to the ground; this was necessary for observations, photography, and spot landings for biological, limnological, and engineering investigations.

Some surveys were conducted with fixed-wing aircraft such as a DeHavilland "Otter" and/or "Beaver"; these surveys were usually combined with the hauling of freight or the relocating of a field camp. Float-equipped, fixed-wing aircraft are able to land in both Upper Paint and Lower Paint lakes, Sulukpuk Lake, and in Akjemguiga Cove on a high tide; however, there are no suitable landing strips located in the Kamishak Bay area, limiting the use of fixed-wing aircraft.

Chenik Lake, which is located approximately 6 km north of Akjemguiga Cove (Figure 2), was utilized as a helicopter base because we were able to stockpile fuel there. Also, the field cabin at Chenik Lake was available for use for extended lengths of time.

Thermograph Monitoring

Every 6 months, water temperatures were remotely monitored with portable thermographs (Peabody Ryan, Model J-180) located in the Upper Paint Lake and in the river just above Paint River Falls at Akjemguiga Cove. The chart had a 30°C span at 1°C increments.

Thermographs had positive buoyancy and were suspended underwater with small anchors. The "O" rings were heavily greased with Vaseline to insure against leakage. Thermographs were secured by a length of plastic-coated airplane cable anchored to a metal stake driven into the bank well above high-water mark. A 1.8-m length of fiberglass rod with a fluorescent orange flag at the top was attached to the stake to facilitate recovery from deep snow and heavy vegetation. Thermographs were checked during every trip to the Kamishak Bay area to insure that the units were operating correctly, even if the 6-month limit was not reached; faulty units were replaced with operative ones.

Limnological/Biological Surveys

Since no previous baseline data have been gathered from the headwaters of the Paint River system, limnological and biological surveys were conducted on Upper and Lower Paint lakes and the Paint River. A DeHavilland "Otter" was used to fly a two-man crew, their camp, and sampling gear to Upper Paint Lake. A temporary camp was established on the east shore of the lake, and a portable single-sideband radio was used to make contact with Homer. A six-man, rubber Zodiac raft, powered by a 4-HP outboard, was used to survey both lakes.

Physical/Chemical Parameters:

A portable fathometer was used to develop bathymetric maps for both lakes. Depth readings were recorded at timed intervals on predetermined transects. Contour lines at 3-m intervals were recorded.

Dissolved oxygen and temperature were measured electronically with a Yellow Springs Instrument (YSI), Model No. 51B. Vertical profile measurements were taken at predetermined lake stations.

Stream flows were determined in all measurable inlet streams and major outlets with a Model-668 Gurley Teledyne flowmeter. Streams were listed and flows recorded on the bathymetric maps.

Freshwater plankton samples were taken at three stations in each lake. Two vertical hauls were made at each station with a 0.5-m-diameter net having 80 μm mesh. Water filtered by the net was calculated by determining the cylinder of water strained by the plankton net; "net efficiency" was not applied. Samples were preserved in 5% buffered formalin in prelabeled plastic containers.

Saltwater zooplankton population levels were monitored by sampling three stations in both Akjemguiga Cove and Amakdedulia Cove. Plankton was sampled with a 0.5-m-diameter, 80-μm mesh, conical plankton townet. The net was fitted with a flowmeter to estimate the volume of water filtered.

All of the horizontal tows were made in as identical a manner as possible. Duplicate 5-minute tows were made in water as shallow and close to shore as practical, usually at a depth of 2 m or less and within 20 m of shore. The tows were made from a 6-man Zodiac rubber raft with a 6-m-long towline attached to the stern. The depth of the plankton net was dependent on the speed of the raft, but it usually sampled within 1 m of the surface.

Environmental factors, including dissolved oxygen (ppm), pH, salinity (o/oo), temperature, and general weather and tidal conditions, were recorded during sampling at each station. The time and duration of the tows and the cumulative readings from the flowmeter were recorded.

At the completion of each tow, the plankton net was thoroughly rinsed over the side of the boat. Care was taken to insure that the contents of the plankton net were not contaminated with unfiltered water. Final rinsing was done with a wash bottle. The contents of the cod-end of the plankton net were emptied into a 473-m, screw-top, widemouthed jar and preserved with a 5% buffered formalin solution. The jars were labeled with the station and date and put into a padded plywood box for protection.

After each tow was completed, a Secchi-disk transparency measurement was taken to estimate the compensation depth in the general area of the station. Attempts were made to conduct all tows within the same photoperiod (0800-1200 hrs), but this was not always possible.

A binocular microscope and a 1-ml Sedgewick-Rafter (S-R) counting cell were used to identify and enumerate both freshwater and saltwater plankton samples. Identification and nomenclature followed Fulton (1968). Plankton samples were thoroughly agitated to make certain that the organisms were evenly distributed within the sample jar. While the plankters within the jar were still in motion, a 1-ml subsample was removed using a 1-ml syringe-type sampler. This subsample was then carefully placed upon the S-R cell and spread over the entire cell. The subsample was placed under the microscope and allowed to settle so that it could be more easily examined; a separate count was kept of calanoids, harpacticoids, decapods, or copepod nauplii. The results were recorded, the cell cleaned, and the entire process repeated again for each sample. Subsamples were then averaged.

The volume of water (V) sampled was computed using the formula:

$$V = \pi r^2 d;$$

where V = volume of water sampled, π = the constant 3.141592, r = radius of the plankton net (0.25 m), d = distance towed. The distance towed was calculated from a time-versus-distance graph included with the flowmeter on the net. The number of organisms (N) was calculated using the formula:

$$N = \frac{n}{Vss} \times \frac{V}{Vs};$$

where n = number of organisms in averaged subsample, Vss = the volume of the average subsample (usually 1 ml), Vs = the volume of the plankton sample jar (473 ml), and V = the volume of water sampled by the plankton net.

An Eckman bottom sampler was used to collect benthos. Three replicate samples were collected at each station and preserved in formalin and rose bengal stain in plastic jars. General observations of substrate along shorelines were also noted. A gill net having panels of several mesh sizes ("variable mesh") and sport gear were used to sample fish-species composition and size ranges.

Paint River Float Trip:

In 1979 a ground survey of the entire main Paint River system was conducted from Lower Paint Lake to the confluence of Sulukpuk Creek and Paint River (Figure 2). The survey was cooperatively conducted with CIAA assistance. Two inflatable rafts were used to float the river system.

All equipment was flown to Sulukpuk Lake in a DeHavilland "Otter". Extra food, radios, antenna, and other miscellaneous supplies were cached at the edge of the lake. Supplies and gear needed for the float trip were then ferried up to Lower Paint Lake Falls (Figure 2) in a helicopter. One night was spent at the falls area preparing for the float trip. Rafts were inflated, and food, fuel, and personal gear were made waterproof in special fiberglass containers.

General observations were made on river-bottom conditions. Special emphasis was placed on observation of (1) suitable spawning substrate, (2) indications of severe flooding or scouring conditions, and (3) natural fish barriers; i.e., beaver dams, rock falls, and native-fish populations.

When the confluence of Sulukpuk Creek and Paint River was reached, the rafts were towed upstream into Sulukpuk Lake; camp was set up at the cache to await pickup by floatplane.

Preemergent Fry Surveys for Broodstock Investigations, 1983:

In April 1983, preemergent-fry surveys (broodstock screening and fry indexing) were conducted in Bruin Bay and the Paint River estuary. A preemergent pump and collection net were used to collect salmon fry samples. Fry samples were placed in labeled whirl-pak bags. Samples were frozen and shipped to the FRED Division Pathology Section in Anchorage for analysis.

Experimental Pink Salmon Fry Stockings

From 1980 to 1983, pink salmon fry were released into the Paint River system. These fish originated from Tutka Hatchery, in Kachemak Bay. Release sites for these pink salmon fry were approximately 8-12 km upstream from the Paint River mouth (*see* Figure 2). These sites needed to be a sufficient distance from salt water so that the fry could imprint to the system; they also had to be near areas suitable for helicopter maneuvering. The stream was braided in the release-site area, providing slower moving water that would allow for the rest and acclimation of fry after transport.

To evaluate the adult return and to check for possible straying back to the Tutka Creek parent stream, a percentage of the fry released in the Paint River system in 1980 and 1981 were marked by excising the adipose and left ventral (AdLV) fins. In both years, a goal of 30,000 marked fry was established. Both marked and unmarked fry destined for the Paint River were held inside the Tutka Hatchery for only a short period until sufficient numbers were accumulated and weather conditions were suitable for transport. In 1980 all fry were vaccinated against the disease Vibrio prior to transport.

Prior to the fry transport, fuel was cached at St. Augustine Island and Chenik Lake so that it could be used for the return flights of the helicopters. The fuel was transported to these caches by helicopter.

A Bell Jet Ranger helicopter was used to transport an empty 1,900-liter-capacity transport tank from Crooked Creek Hatchery, located on the Kenai Peninsula, to the intertidal flats at the Tutka Hatchery. Because of load constraints, personnel had to accompany the fish-transport helicopter in a separate helicopter. The transport tank was filled with 950 liters of fresh water from the Tutka facility by means of a gravity-feed pipeline. A 45-kg, 2,000-p.s.i. oxygen bottle was mounted on the transport tank to supply oxygen to the water. The fry were sent down the gravity-feed pipeline and transferred into the transport tank. The hatch was then secured and transport slings tested before lift-off. Both helicopters flew to the Paint River system release site (8 km to 12 km upstream from the mouth of the Paint River). Personnel on the ground removed the slings from the transport tank that had been set down in a side channel of the mainstream. Tank-water temperature was checked against the stream temperature, and the tank water was tempered (when necessary) to allow for acclimation. Personnel that were placed at intervals downstream noted condition and reaction of fry as they were released from the tank.

Pink Salmon Fry Sampling:

In 1982 and 1983, fry transport-feasibility work included over-the-falls mortality tests. The transport was carried out in the same manner as during the two previous years. Fry-trap frames, float systems, collection boxes, and helicopter fuel were previously transported to the Paint River mouth for the project.

The below-falls float system was installed and secured to two naturally formed rock columns on either side of the river at the mouth of the canyon. Four panels of 4- x 4-m lead material were sewn onto the left-hand side of the float system. The upstream collection boxes and traps were carried above the falls. The stream-water flow generally ran high, estimated at over 45 m^3/s (accurate measurement was not possible), and appeared to be slightly turbid. The elevation level of the river fluctuated from 8 to 127 cm within a day because of melt-off in the upper drainages.

Radio contact was made with Homer to confirm the exact time of the pink salmon fry transport. The net was sewn into the below-the-falls trap frame and bear damage to the collection box was repaired. The trap and collection box in the float system were installed and lengths of iron reinforcing bar ("rebar") were secured on the leadline. (Unfortunately, the current was too strong for the rebar to sink the lead panels.) Holding pens were secured at the top of the falls, and an area was marked off with red flagging for the transport tank to be off-loaded. Approximately 50,000 fry were to be placed in holding pens for further experiments.

In 1982 a final effort was made to place a fry trap in the area above the falls (approximately 45 m upstream from the falls). However, high water made the positioning of a trap almost impossible. The trap was held in place with lines to the bank and sandbags at its base. The use of stakes was not possible because of bedrock in the river bottom. One lead was made with rigid panels fronted with smaller mesh net from the trap mouth to the bank.

Fry were dyed orange with Bismark Brown Y Stain and released above the falls. Fry were caught and examined for any ill effects in the below-the-falls floating-trap system. To qualitatively check for the possibility of sublethal damage to the fry, oranges, apples, and water balloons were released above the falls and then collected and examined for damage below the falls.

Aerial Transport Pathology Study:

This study was conducted to determine if there are any adverse side effects from the lengthy helicopter transport of pink salmon fry to the Paint River system. Samples collected after the 1982 transport indicated that problems may have developed from atmospheric pressure changes attributable to altitude variations.

A tank containing approximately 550,000 pink salmon fry in 1,136 liters of aerated hatchery water was flown suspended below a Bell 212 helicopter from the hatchery to Paint River on 30 May 1983. The duration of the flight was 1 hour and 22 minutes. Maximal flight altitude was 2,300 feet. Changes in altitude were made as slowly as conditions would permit, and total-dissolved-gas (TDG) readings were taken at varying altitudes during the flight. Because the helicopter was not equipped for flying with the tensionometer probes suspended inside the transport tank, a separate 19-liter container of hatchery water was carried within the aircraft for water-testing purposes.

Water and Atmosphere Testing:

Two tensionometers (Common Sensing, Inc.) and one Weiss saturometer were used to measure gas supersaturation. The saturometer was used at the hatchery prior to the flight as a means of calibrating the tensionometer. In the event one machine did not equilibrate quickly or function properly during the flight, each tensionometer was simultaneously read before, during, and after the flight. During the return flight, one tensionometer was used to obtain atmospheric-pressure data. TDG levels were calculated following the method of Nebeker et al. (1976). Both the TDG and barometric-pressure readings were regressed linearly against altitude.

Specimen Examination:

In order to facilitate fry sampling and visual observation of the fry reactions to the transport conditions, a container holding live fry was carried within the aircraft. During the flight, live fish were checked periodically for changes in behavior and anatomy. Five samples of fish were taken during the experiment: (1) normal fish (control) from the hatchery prior to the flight; (2) experimental fish at the beginning of the flight at an altitude of 2,000 feet; (3) experimental fish at the end of the flight before descent; (4) experimental fish at the end of the flight after descent; and (5) experimental fish after their release into Paint River and subsequent capture in fry traps. Live samples numbered 1-4 were placed into Boin's fixative. Those fry captured after release were fixed at the streamside in 10% formalin. This solution was changed to 10% neutral buffered formalin following receipt of the sample at the laboratory. Standard histopathological techniques were used for the five samples of fish.

Adult Return Evaluation

Because of budget constraints and the remoteness of the area, no on-site camp was established at Paint River to monitor adult returns. Instead, the few fishermen in that area were contacted and informed about screening their catch for marked fish. They also agreed to contact the Alaska Department of Fish and Game

(ADF&G) at the first sightings of any fish in or near the Akjemguiga Cove area. In addition, routine surveys were conducted by fixed-wing aircraft to monitor returns.

An inflatable raft, outboard motor, small seine, and gill net with panels of different size mesh were on standby status, in the event that fish showed up in the area; therefore, it was possible to transport the gear to the area on short notice. With the addition of a fish-processing kit, wet suits, and surface diving gear, sampling gear for the 1982 pink salmon adult return was as previously described.

Engineering Surveys

By providing salmonid access above the falls at the river mouth to Lower Paint Lake, the entire Paint River system would be open and available as potential spawning and rearing habitat. Engineering surveys were required to determine the feasibility of constructing fishpasses over these migrational barriers. Surveys were conducted by air and foot, and extensive investigations required on-site work for 2 weeks in September 1981.

RESULTS AND DISCUSSION

Aerial Surveys and Visual Interpretation

Summer 1978:

The first aerial survey was conducted in August 1978. It involved a preliminary study of the feasibility of this potential rehabilitation program. Because of time constraints, only a brief stop was made at the main falls to install a thermograph upstream from the mouth. A brief on-site inspection by the project engineer confirmed that the potential fishpass appeared feasible and warranted further work.

From aerial surveys, the falls below Lower Paint Lake appeared to be passable by fish. On the basis of a subsequent ground survey, this judgment was revised; the Lower Paint Lake Falls are considered a significant barrier to migration.

Winter 1979:

A second aerial survey was conducted later in January of 1979 to determine ice conditions in the system. Although no surface ice was observed on the river, some anchor ice was forming on the river bottom. Both Upper Paint Lake and Lower Paint Lake were covered with 13-cm-thick ice that was mostly free of snow cover.

Another survey in February 1979 revealed that midway downstream on the Paint River, ice was from 26 to 61 cm thick and had a snow-cover depth of 0.9 m. The falls at the intertidal area were completely iced over; there was no visibly moving water. With snow cover at 0.3 m deep, ice thickness was found to be 62 cm on Upper Paint Lake.

Winter 1980:

The winter of 1980 appeared to be more severe than in 1979. A survey in January 1980 revealed that Akjemguiga Cove, which the Paint River flows into, was completely ice covered. Although there was no water showing at the falls, a considerable flow of water could be heard running under the ice. Drifted snow made a detailed ground survey fairly dangerous around the falls area.

Aerial surveys of Dunuletak Creek revealed a 1.6-km-long stretch of open water. This was attributed to groundwater upwelling. Aside from this area, the creek was completely covered with ice. In addition, headwater lakes of the main Paint River were almost entirely iced over.

Upper Paint Lake had one small opening at the main inlet, indicating water flow into the lake. The stream connecting Lower Paint Lake to Upper Paint Lake was completely open. Lower Paint Lake Falls was also open at the steepest part of the falls, but the remaining portions were ice covered. Considerable snow cover and severe drifting were evident in all surveyed areas.

Spring 1980:

In mid-May 1980 a brief survey that was made prior to fry release into the Paint River showed the river and the intertidal area to be completely free of ice. Both the upper and lower lake systems were beginning to break up, and the stream between the two lakes was completely clear of ice. The major inlet to Upper Paint Lake was open at the delta region where it entered the lake.

Spring 1981:

A spring survey in April 1981 revealed open water in the Paint River from the intertidal falls all the way up to the falls at Lower Paint Lake. Both Upper and Lower Paint lakes were completely frozen over, and the interconnecting stream was open. The water level in the river was considerably lower than in past years.

Spring 1982:

A spring survey conducted in April 1982 showed conditions that were very different from those of 1981. The Paint River was completely frozen over with ice and drifted snow, and it was almost impossible to ascertain the outline of the streambed. No water was visible at the falls area, and Akjemguiga Cove had a solid ice cover. Situations like this could have some influence on the survival of future natural fry and those from artificial eyed-egg transplants. These environmental extremes could account for high/low fry survival years in the Kamishak area and lead to speculations on the use of eyed-egg plants as a viable option for brood-stock buildup. Adjacent salmon-producing streams, such as the McNeil River, showed the same characteristics of ice and snow cover.

Thermograph Data

Long-term data from the Ryan 90/180-day thermographs were unfortunately intermittent because of malfunctions of the units. The main problem was water leakage; graph paper also jammed on the take-up reel and ultimately tore. Recently, these two problems have been solved; the company sent out new improved take-up reels, and the o-ring seals were carefully waterproofed with grease.

From September through December 1978, the average monthly water temperatures in the Paint River above the intertidal falls area were 7.5°, 2.9°, 0.0° and 0.0°C, respectively. The average monthly water temperatures for June through August 1980 were 5.8°, 8.3°, and 9.6°C, respectively. Detailed thermograph data are presented in Figures 3 and 4.

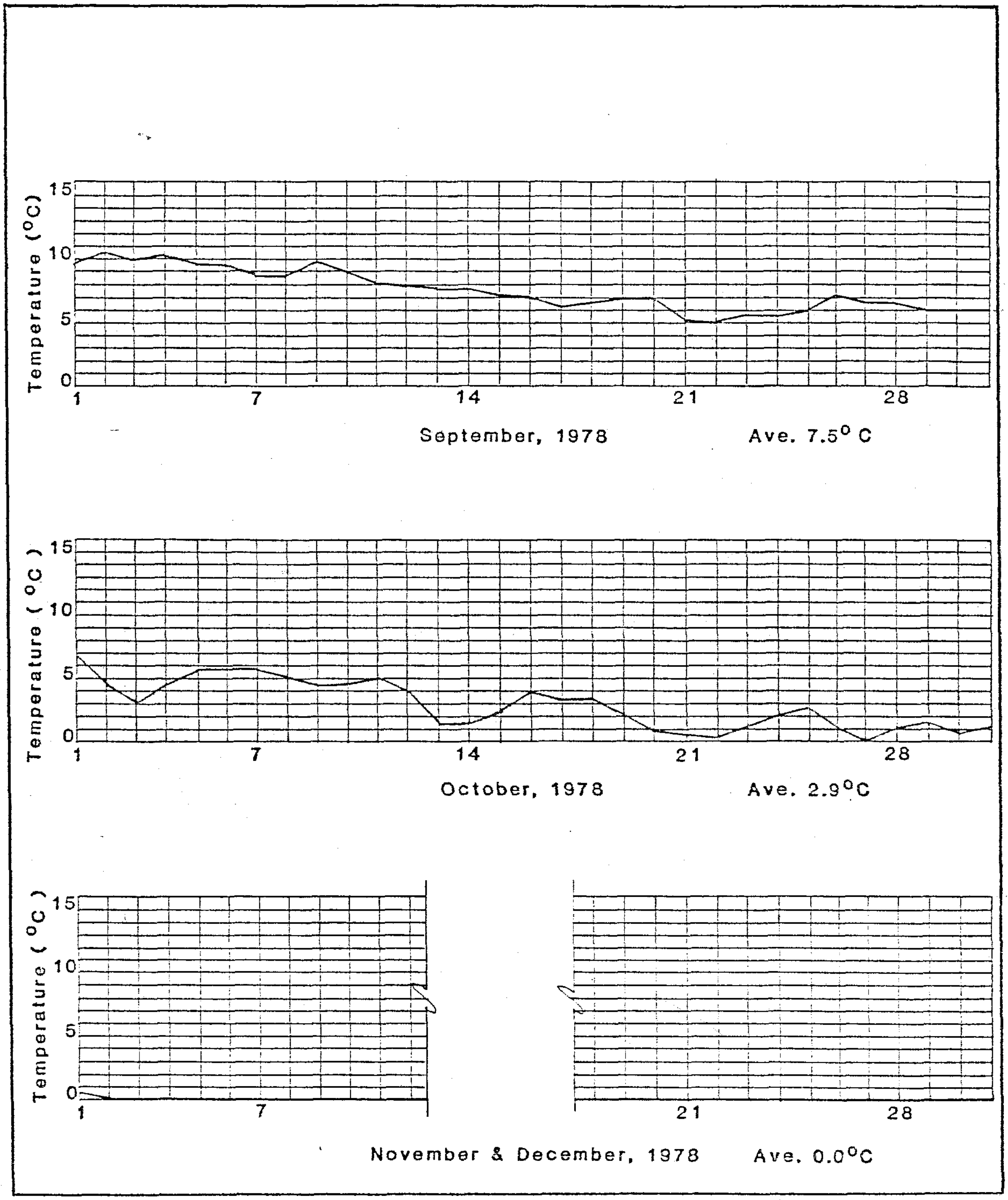

Figure 3. Water temperatures at Paint River Falls at the river mouth, Kamishak Bay.

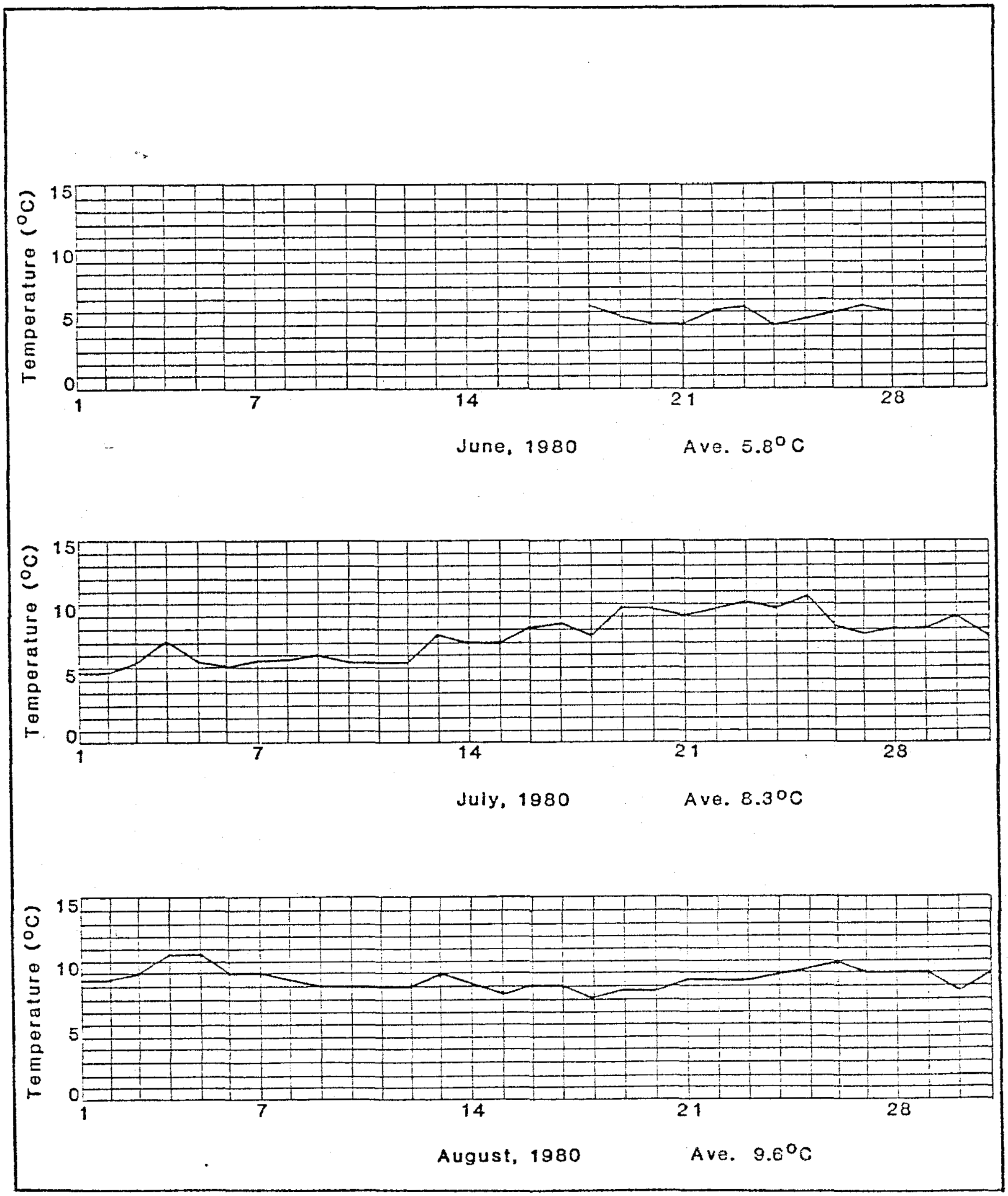

Figure 4. Water temperatures at Paint River Falls at river mouth, Kamishak Bay.

Physical, Limnological, and Biological Data

Physical Characteristics:

Dissolved oxygen (DO) and temperature profiles were taken in June 1979 at three stations in Upper Paint Lake: south end (P_4), mid-lake (P_5), and north end (P_6) (Table 1; Figure 5). No definite stratification of DO and temperature levels was observed. There was a gradual decline associated with depth. No low oxygen levels were encountered, even near bottom.

Temperature and DO profiles were taken from the delta formed by the major inlet stream. Surface DO was 10.8 ppm, and at 15 cm above the bottom, DO was 10.0 ppm. Surface and near-bottom (15 cm) temperatures were 6.5°C and 5.9°C, respectively, demonstrating the cold water runoff influence immediately after rainfall in the western ridge system.

DO and temperature profiles were also taken at three stations in Lower Paint Lake: south end (P_1), mid-lake (P_2), and north end (P_3) (Table 2; Figure 6). Again, there was no definite stratification of oxygen observed.

Water clarity was such that the Secchi disc could be seen on the bottom (maximum 10 m) at all three stations. Table 3 shows water-quality analysis results from the lakes in the Paint River system.

The potential productivity of both Upper and Lower Paint lakes, based on conductivity and total alkalinity data, appears to be identical. The Upper Paint and Lower Paint lakes rate lower than lakes having high potential productivity such as Chenik, Hidden, and Karluk lakes but higher than lakes such as Delight, Desire, and Eshamy (Appendix A). Although other means of assessing productivity are available (e.g., standing crop), it is defined here as a function of alkalinity or inorganic carbon.

Table 1. Physical and chemical parameters of Upper Paint Lake, Kamishak Bay, June 1979.

Station (Fig. 5)	Depth (m)	Dissolved oxygen (ppm)	Water temperature (°C)	Secchi transparency (m)
(P_4)	surface	10.4	7.4	
	mid-depth (10)	10.1	6.2	9.5-10.5
	bottom (20)	9.6	5.2	
(P_5)	surface	10.2	7.2	
	mid-depth (16.5)	9.8	6.0	9.5-10.5
	bottom (33)	8.8	5.0	
(P_6)	surface	10.2	8.2	
	mid-depth (5)	10.1	8.0	10.0
	bottom (10)	9.6	6.5	

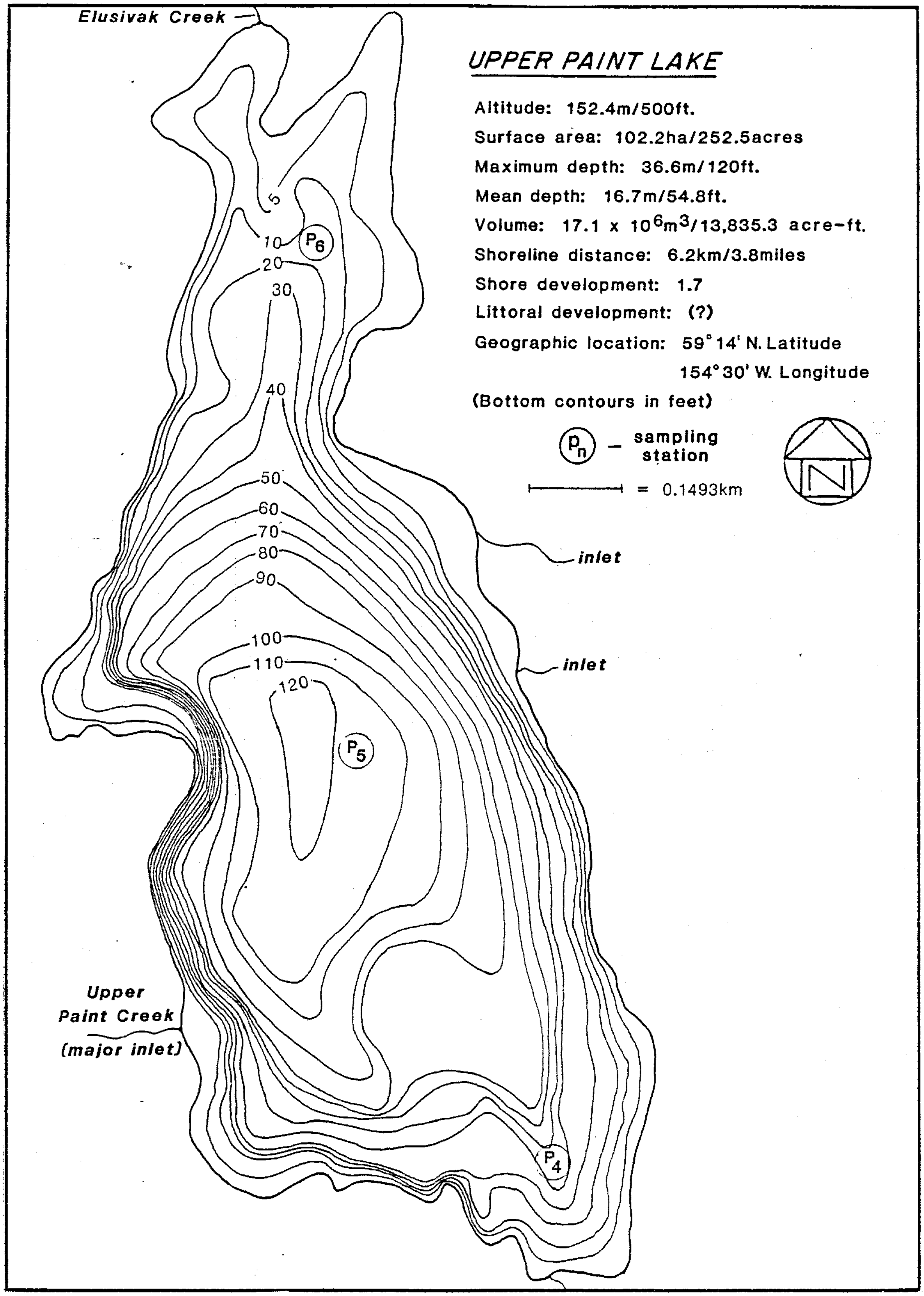

Figure 5. Bathymetric map of Upper Paint Lake showing sampling stations.

Table 2. Physical and chemical parameters of Lower Paint Lake, Kamishak Bay, June 1979.

Station Fig. 6	Depth (m)	Dissolved oxygen (ppm)	Water temperature (°C)	Secchi transparency (m)
(P_1)	surface	8.8	7.5	
	mid-depth (5)	9.0	6.6	10.0
	bottom (10)	8.5	5.8	
(P_2)	surface	8.9	7.2	
	mid-depth (4.5)	9.0	6.9	9.0
	bottom (9)	9.1	6.0	
(P_3)	surface	9.4	8.0	
	mid-depth (2.5)	9.3	7.8	5.0
	bottom (5)	8.9	7.0	

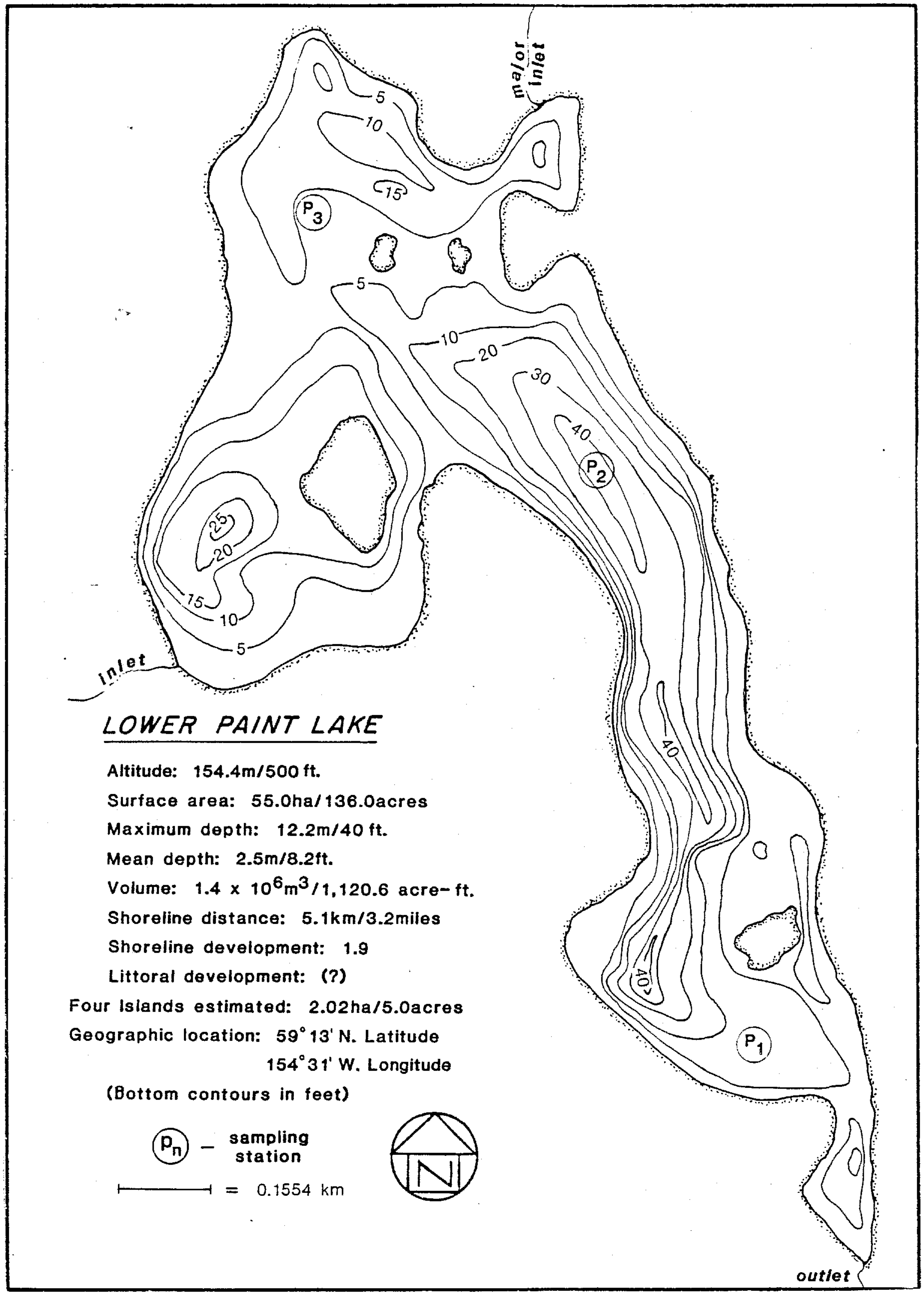

Figure 6. Bathymetric map of Lower Paint Lake showing sampling stations.

Table 3. Chemistry of water samples taken in Paint River system lakes, Kamishak Bay, 1979.

Location	Sample date	Analysis date	Depth (m)	pH (lab)	Conductivity (Mhos/cm)	Alkalinity (mg/l $CaCo_3$)	Total hardness (mg/l $CaCo_3$)	Total dissolved solids (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	T.P.[A/] (g/l-p)
Elusivak Lake	6/29/79	7/25/79	Sub-surf	6.66	41.0	6.5	11	39	5	0	7
Elusivak Lake	6/29/79	7/25/79	8.0	6.81	38.0	7.0	11	37	5	0	6
Upper Paint Lake	6/29/79	7/11/79	Sub-surf	6.93	36.0	6.0	6	25	-	-	5
Upper Paint Lake	6/29/79	7/11/79	18.3	6.72	24.0	5.0	6	22	-	-	9
Lower Paint Lake	6/29/79	7/11/79	Sub-surf	6.62	25.0	7.0	4	22	2	0	5
Lower Paint Lake	6/29/79	7/11/79	6.1	6.30	55.0	7.0	6	28	2	0	6
Sulukpuk Lake	6/29/79	7/25/79	8.0	6.30	17.6	3.0	3	17	1	0	4

A/ T.P. = Total Phosphorus

Plankton Sampling

Upper Paint Lake:

Plankton sampling was completed by duplicate vertical hauls conducted at three stations (P_4, P_5, and P_6) in Upper Paint Lake (*see* Figure 5). The overall average density was 2,800 organisms/m³; the highest density, which was recorded at station P_5, was 4,750 organisms/m³. Dominant species were cyclopoid, copepods, and cladocerans. These densities were relatively low, compared to samples collected during the same period at Chenik Lake (6,340 organisms/m³) and Leisure Lake (20,050 organisms/m³). However, the Upper Paint Lake temperature was still cool (7° to 8°C) in June 1979 (the lake elevation is 170 m, much higher than the other two lakes).

Lower Paint Lake:

Duplicate plankton samples were collected at three stations (P_1, P_2, and P_3) on Lower Paint Lake (*see* Figure 6). The overall average density of 362 organisms/m³ was much lower than that of Upper Paint Lake. The highest density recorded was 830 organisms/m³ at station P_1, near the outlet of the lake.

Kamishak Bay:

Duplicate plankton samples were collected at three stations in Akjemguiga and Amakdedulia coves (Figure 7) during June 1982. Station 1 yielded 197 organisms/m³, Station 2 yielded 779 organisms/m³, and Station 3 produced only 17 organisms/m³. The major organisms were calanoids, barnacle nauplii, and harpacticoids, respectively. The reason for the low numbers of organisms/m³ may have been due to the low water temperatures recorded at the time (range 5.5°- 8.0°C); however, at some period food availability for fry in the area must be fairly substantial

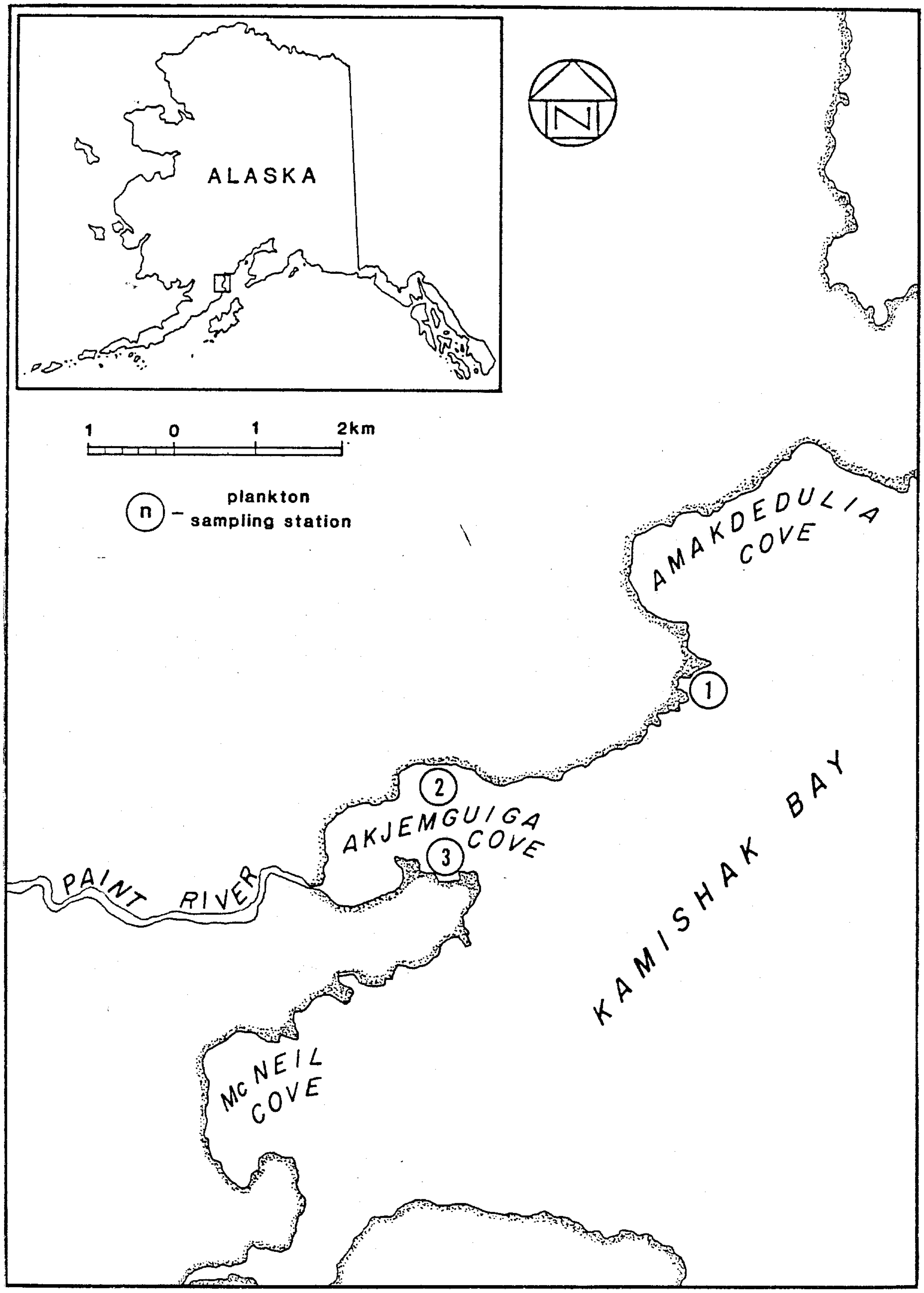

Figure 7. Plankton sampling stations in Akjemguiga and Amakdedulia coves, June 1982.

to support the large runs of salmon on either side of the Paint River at Mikfik Creek, McNeil River, and Bruin Bay.

Fisheries

In 1979 a variable-mesh gill net was fished at six different stations in Upper Paint Lake; the average set was for 2.5 hours. A total of five grayling, *Thymallus arcticus*, nine round whitefish, *Prosopium cylindraceum*, and two lake trout, *Salvelinus namaycush*, were collected (Table 4); average weights and fork lengths, respectively, are as follows: (1) grayling, 463 g and 360 mm; (2) whitefish, 381 g and 324 mm; and (3) lake trout, 3.0 kg and 500 mm. The largest lake trout (4.7 kg) had ingested a grayling (457 mm). All adult fish were heavily infested with internal parasites.

If this system is selected as a sockeye salmon release and production site, predation and competition would be a factor to consider. Gill net sampling also revealed grayling, lake trout, and round whitefish in Lower Paint Lake.

Potential Spawning Areas within the Lake Systems

Surveys along the east shore of Upper Paint Lake indicated its limited potential as a sockeye salmon spawning area because of an absence of suitable spawning substrate in less than 3 m of water. The remaining shoreline was composed of rocky, boulder-type substrate. The southeast shore and the area near the outlet appeared to provide the best substrate for potential shore spawning.

Seven minor inlets feed the lake; their flow rates range from 0.03 to 0.7 m^3/s, and only limited spawning areas are available in the larger streams. The major inlet is located on the western shore of the lake and has a summer flow (recorded in June 1979) of 15 m^3/s (*see* Figure 6). Excellent spawning substrate was found in the first 1.2 km of that stream. Gravel, ranging in

Table 4. Results of test gill net fisheries in both Upper and Lower Paint lakes, Kamishak Bay, June 1979.

Lake	Species	Avg fork length (FL) (mm)	Range (mm)	Average wt (g)	Range (g)	(n)
Upper	grayling	360	210-420	463	170-610	5
Upper	round whitefish	324	126-420	381	30-610	9
Upper	lake trout	599	498-700	2,975	1,250-4,700	2
Lower	grayling	404	372-425	592	550-650	3
Lower	round whitefish	223	132-405	190	20-525	3
Lower	lake trout	535	-	1,700	-	1

size from 2.5 to 7.5 cm, was intermixed with very little sand. There appeared to be essentially no siltation or glacial sedimentation within the stream. An aerial survey conducted at a later date indicated more spawning area further upstream. This inlet, tentatively named Upper Paint Creek, showed extremely good potential for supporting large numbers of inlet-spawning sockeye salmon.

In June 1979 the estimated outlet flow of Upper Paint Lake was 5.7 m^3/s; excellent spawning substrate is available between the two lakes. It appears that this would provide an incubation area where the warmer waters of the upper lake would circulate through the outlet channel into the lower lake.

Shore surveys indicated essentially no shoreline spawning habitat in Lower Paint Lake. There appears to be only one other minor inlet, and no suitable spawning areas were observed. The major inlet from the upper lake provides spawning substrate as previously described. Because the lake is shallow, it could become considerably warmer in the summer months, and depending upon the productivity and subsequent plankton densities, it could provide limited rearing area for sockeye salmon.

Paint River Surveys

Float Trip:

The float-trip survey conducted in July 1979 confirmed earlier aerial surveys that revealed excellent spawning areas available on the Paint River from Lower Paint Lake Falls to the mouth of the river. There was adequate water flow, and no siltation or glacial sedimentation were observed. We saw very few fish during the trip, and gillnetting efforts in one large pool yielded no fish. One small rainbow was caught on sport gear at the base of a small set of falls. Some fish were observed in eddies but were not identified.

Aerial Survey

Elusivak Lake:

From 27 to 29 June 1979, a detailed aerial (helicopter) survey was conducted on the Paint River system and its tributaries; its purpose was to determine the extent of suitable spawning areas, measure stream flows, obtain water samples, check thermographs, and obtain plankton samples in the headwater lakes.

A second major inlet stream into Upper Paint Lake was discovered at the upper northwest lake shore; this particular stream had been overlooked on previous lake studies. For convenience, the stream was tentatively named Elusivak Creek, because it drains Elusivak Lake. Elusivak Lake is about the same size as Lower Paint Lake (*see* Figure 2). The water temperature of Elusivak Creek was 13.5°C and flow was measured at 0.6 m^3/s; suitable spawning substrate was evident throughout its entire length (0.4 km). Elusivak Lake has two good spawning beaches near the inlet of the lake, and the inlet stream has suitable spawning substrate throughout its entire length. The helicopter hovered over the lake, while a depth reading with a fathometer was taken. The deepest portion of the lake was first identified from the air; it was then measured. This procedure was used on all the lakes. Elusivak Lake was at least 7 m deep at the area measured.

It was impossible to conduct vertical plankton tows in the lakes, because the helicopter could not maintain a stationary position on the water. Upper Paint Creek was identified as the major inlet into Upper Paint Lake; good spawning areas were observed up to the falls (1.6 km) coming out of a deep gorge. The small lake that it drains was too shallow (4 m) for overwintering fish survival.

Paint River and Tributaries:

A stream-flow measurement was taken on the Lake Fork River, approximately 1.6 km below the Lower Paint Lake Falls. The stream flow at that time was recorded at 4.6 m^3/s, and the water temperature was 12.5°C. After 30 minutes of fishing with sport gear, no fish were caught.

The Paint River was very rocky; large boulders were evident at Lake Fork River and for about 1.6 km upstream; however, good spawning and deep resting-pool areas began there and continue to the Pilot Knob Fork (*see* Figure 2). The North Fork has two falls that appear to be barriers to fish passage. There does not appear to be enough spawning area above the falls to merit fishpass siting. From the air, fish were observed in the pools but were unidentifiable. They appeared to be approximately 30 to 40 cm long. An attempt was made to catch them on sport gear; although two were hooked, none were landed. However, one appeared to be a Dolly Varden, *Salvelinus malma*.

The Paint River, from Pilot Knob Fork to Lake Fork River (Figure 2), appears suitable for rearing but has questionable spawning areas. In the stream, there are large rocks and boulders, intermittent patches of spawning substrate, and no evidence of siltation. The main Paint River generally appears to have suitable spawning substrate all the way to the mouth at the intertidal falls.

About halfway up the system, Kenty Creek flows into the Paint River from the west (Figure 2). Good spawning areas were observed in the lower reaches (near the confluence) and in one stretch of the upper reaches. Overall, this creek appears to have poor spawning substrate. There was also some evidence of erosion in the upper reaches. Kenty Creek had a stream flow of 4 m^3/s, at the time of survey.

Sulukpuk Lake:

Although the maximal depth of Sulukpuk Lake was recorded at 6.6 m, approximately 75% of the shoreline substrate is considered suitable for sockeye salmon spawning. The inlet stream has a small section that appears to be suitable for spawning, but for the most part it is composed of sand and mud substrate. Approximately 200 round whitefish were observed along the east shoreline and another 100 along the west shoreline. Grayling were later observed in this system. The outlet stream is considered ideal for spawning, and the stream flow at that time was measured at 1.3 m^3/s.

Dunuletak Creek:

A major tributary of the Paint River, Dunuletak Creek, was also surveyed (Figure 1). Good spawning habitat was observed at (1) the fork near the headwaters to the first lake on the east and (2) downstream to the confluence of the Paint River. All of the lakes draining into the Dunuletak are very shallow and probably unsuitable as spawning areas. An unidentified fish (25 to 30 cm) was observed in one of the pools in the lower reaches. A stream flow of 7.1 m^3/s was measured in the lower area.

Overall, the Paint River, including its major tributaries and headwater lakes, has excellent spawning habitat and water conditions (clarity and flow) to support the initiation of salmon runs into the estimated 40-km system.

Preemergent Fry Surveys

Bruin Bay:

Bruin Bay was chosen as a potential pink and chum salmon broodstock source for the Paint River Project. The area's proximity to the Paint River is desirable from a genetic standpoint.

During the spring of 1983, a number of river-bottom areas were examined for preemergent fry before any fry were found. A few pink salmon fry that were about 80% buttoned-up were encountered. The first chum salmon redd discovered produced over 200 chum salmon fry that were about 85% buttoned-up. Another dig provided over 50 eyed pink salmon eggs but no fry. The last dig produced over 200 pink salmon fry that were about 80% buttoned-up.

Twelve sites were sampled in a 135-m stretch of the stream; water temperature was 2.0°C. Fry samples were separated by species into separate plastic bags, frozen upon return to Homer, and forwarded on to the Pathology Section in Anchorage for analysis. Results indicated that the stocks of both species were probably suitable as brood sources (Appendix B and Appendix C).

Paint River:

Although ten preemergent fry pump samples were taken in an area where intense pink salmon intertidal spawning activity was observed last summer, nothing was found, not even dead eggs or egg shells. However, as evidenced by the trenches in the gravel, there had been considerable scouring by ice movement. Considerable amounts of silt were also deposited in the gravel. In addition, many amphipods and isopods were found in the digs, indicating there may have been severe predation upon the eggs. Water temperature was measured at 1.2°C during the sampling.

It is difficult to ascertain whether the pink salmon that spawned intertidally last summer had sustained poor instream survival or an early emergence in the spring under the ice. Early emergence was possible because these fish would have been exposed to salt water throughout the entire incubation period; this exposure would have allowed a higher accumulation of thermal units, compared to freshwater incubation.

Experimental Pink Salmon Fry Stocking

This part of the Paint River project was conducted to determine various aspects of fry stocking to that system; e.g., downstream mortality, imprinting efficiency, marine survival, and orientation of returning adults. The goal was to determine the ultimate feasibility of developing brood sources for the Paint River system through fry-stocking programs. Part of the goal was accomplished by four pink salmon fry releases from 1980-1983 (Table 5).

1980 Stocking:

In May 1980 a joint effort by CIAA and FRED Division resulted in the marking of 33,100 (AdLV) pink salmon fry (Tutka Creek 1979 brood year) destined for the Paint River.

A total of 554,000 late-emergent Tutka Hatchery fry (0.21 g), including marked fry, were held in fresh water for 8 days. During that time a limited feeding program was initiated; freshwater temperature in the hatchery ranged from 5° to 6°C. On the sixth day of holding, all fry were vaccinated for Vibrio by Kent Hauck, Pathology Section. The operation was accomplished in about an hour's time.

The empty transport tank was brought from Homer to the Tutka Hatchery where it was filled with 946 liters of hatchery water. From the hatchery, fry were sent down a 50-mm PVC pipe and netted into the tank. The 45-kg, 2,000-psi oxygen bottle mounted on the side of the transport tank was turned on as soon as the first fish were sent down the pipe.

The transport took approximately 90 minutes. The tank was set down in a side channel of the main Paint River about 8 km upstream from the mouth. Tank temperature was measured at 5.0°C, while stream water was 4.5°C, precluding the need to temper the

Table 5. Paint River pink salmon stocking and marking summary, Kamishak Bay, 1980-83.

Brood year	Hatchery origin	Date stocked	Estimated average number	size	No./Mark (AdLV)	Year return
Tutka Cr 1979	Tutka Cr	05/80	554,000	0.21 g	30,300	1981[a]
Tutka Cr 1980	Tutka Cr	05/81	509,000	0.23 g	30,700	1982[b]
Tutka Cr 1981	Tutka Cr	06/82	405,000	0.24 g	-0-	1983[c]
Tutka Cr 1982	Tutka Cr	05/83	502,000	0.23 g	-0-	1984[d]

a/ Only one verified mark recovered in Kamishak Bay. Several sightings of fish homing back to the falls have varied between 25 and 600. Survival estimated at 0.10%.

b/ Aerial surveys conducted by Commercial Fish Division confirmed at least 2,400 adult pink salmon returning and staging in the intertidal area below the falls. An additional 300 pink salmon were harvested by commercial seiners. In addition, another 2,000 pink salmon were observed at the nearby McNeil River system. Since there have never been any pink salmon returns to that system, these fish were attributed to the Paint River release. Total run accountability was estimated at 4,700 fish, or 0.92% survival.

c/ No adults returned from this stocking. 1981 brood year fry were obtained from the last 5% of the emerging fry at the hatchery and were considered poor quality because of lengthy holding periods resulting from bad weather prior to transport.

d/ Based on survival rates ranging from 0.1% to 1.0%, the adult return could range between 500 and 5,000 fish.

tank water. Approximately 5 psi of oxygen remained in the bottle. All fry were released directly into the side channel. Personnel were stationed at different intervals downstream from the release site to observe the fry. The fry appeared to first attempt to hide and bury themselves in the rocks and gravel, but soon they distributed themselves throughout the water column in the shallow side channel. Water conditions were quite calm and clear, allowing the fry time to acclimate before moving out into the mainstream of the Paint River. At less than 12 fish, mortality was minimal.

Approximately 2,000 fry from this group were left behind at Tutka Hatchery and placed in a net bag at the rearing pens in the lagoon to determine any immediate, adverse effect of saltwater exposure after being held in fresh water for 8 days. After 72 hours in salt water ranging between 26 and 28 ppt salinity and a temperature of 5.0°C, no mortalities were observed.

After the fry were released, a brief survey of the upper reaches of the Paint River and lakes showed that the river was completely open and ice on the upper and lower lakes was just starting to break up.

1981 Stocking:

On 27 May 1981 an estimated 509,000 pink salmon fry were transported and released into the Paint River, approximately 12 km upstream from tidewater; 30,700 fry were marked with valid AdLV clips. The mean weight at time of release was approximately 0.23 g.

It took about 80 minutes to move the load from the Tutka Hatchery to the Paint River release site. Fry were liberated almost immediately following their arrival at the release site. Fish behavior appeared to be normal throughout loading, transport, and release. Approximately 200 fry were dead at time of release.

From their color it appeared that these fry had died prior to the transport, and it was assumed that these fish had perished in the hatchery raceways before the loading of the transport tank. Tank water temperature was 3.9°C when loading had been completed. While the river temperature was 4.2°C prior to release, the tank water temperature had risen to 4.4°C.

1982 Stocking:

At 1230 hours on 1 June, the helicopter carrying the transport tanks arrived at a designated area near the the top of the Paint River Falls and was unhooked. Approximately 50,000 fry were transferred with dip nets into the two holding boxes for over-the-falls mortality experiments. Tank temperature was 8°C and the river temperature was 4°C. No tempering was possible because of the short time available. The helicopter then moved the transport tank upstream approximately 10.5 km where personnel were waiting to direct the release of the major group of fish.

Because it provided a lower-velocity current that would allow for resting after the 90-minute transport time as well as warmer stream water for acclimation, a side channel of the main Paint River system was selected as the release point for the major group of pink salmon fry. At 1330 hours, approximately 355,000 newly emergent fry were released. Tank temperature had increased up from 4°C at the Tutka Hatchery to 8°C at the release site. Ambient stream temperature in the side-channel release area was 6°C; stream water was used to temper the tank water so that some acclimation would be possible for the fry.

The warm air temperature that day (about 18°C) had an influence on the water temperature increase during the 90-minute air transport. Future work in warm weather should include icing down the tank. Loading at the hatchery took about 45 minutes and the fry were somewhat stressed; however, with fewer than 500 mortalities, they did well during transport. It appears that most of those died prior to transport.

A total of 1,400 liters of oxygen was used in the 852 liters of water held in the 1,893-liter transport tank. The oxygen-delivery rate was approximately 15 liters/minute.

1982 Stream Residence and Over-Falls Mortality Testing

In order to determine how long the released fry remained in the river, fry traps were installed above the outlet falls to intercept the first fry moving downstream. Another downstream fry trap was set up in the intertidal area below the falls to check on possible adverse effects of passing over the main falls. The main group of pink salmon fry were released at 1330 hours, approximately 10.5 km upstream; at 1510 hours there were 15 pink salmon fry observed in the upstream trap, which only fished approximately 1% of the river width. The fry appeared to be in good condition and were swimming in a calm eddy when captured in the trap. A check of the downstream, intertidal trap was then made. At 1600 hours there were seven pink salmon fry in the collection box, and all appeared to be in good shape. Unfortunately, twelve pink salmon fry were killed in the throat of the trap because the fast current pushed them partially through the net mesh. The downstream, intertidal trap fished approximately 5% of the river width at that location. Table 6 presents the catch data for the two traps.

In order to check the potential for mechanical damage, seven balloons and six oranges and apples were tossed over the falls. Five balloons and two fruit were retrieved at the downstream trap, while the others were caught up in back eddies in the intertidal canyon. Elapsed time for the items were 4-7 minutes through the canyon. All balloons and fruit appeared undamaged.

Of the 50,000 pink salmon fry in the test group, about 200 of them were dyed with Bismark Brown Y stain. Because of mechanical difficulties with the oxygenation system, the fry were not held long (15 minutes); however, in that time the fry colored

Table 6. Pink salmon fry catch data for two instream fry traps at Paint River Falls, Kamishak Bay, June 1982.

Date	Time	Upstream trap Live	Upstream trap Dead	Downstream trap Live	Downstream trap Dead
6/1/82	1600 hrs	15	0	7	12
6/1/82	1800 hrs	51	6	-	- 1/
6/1/82	1700 hrs	-	-	27	17
6/2/82	0800 hrs	-	-	8	8
6/2/82	0845 hrs	19	16	-	-
6/2/82	1230 hrs	1	3	-	-
6/2/82	1245 hrs	-	-	1	0
6/2/82	1500 hrs	1	0	-	-
6/3/82	0830 hrs	-	-	0	0
6/3/82	1030 hrs	4	8	-	-
6/4/82	0800 hrs	0	0	0	0 2/
TOTALS		91	33	43	37

1/ "-" means no data taken.

2/ Pulled all traps.

sufficiently around the head and fins to be recognized. The dyed fry were released at 1230 hours, and one was caught in the downstream trap at 1245 hours; it appeared to be in good condition. The remainder of the fry were dyed in three lots and released over the falls. In 6 hours, nine fry were caught in the downstream, intertidal trap and five were dead. All were preserved in formalin for later examination.

On 3 June two schools of pink salmon fry were spotted at low tide in the west-beach shallows of Akjemguiga Cove, approximately one mile away from the Paint River mouth. At mean-low (0.0) tide, the water in the cove was fresh tasting. Even though the majority of the fry flushed out of the river system within 9 hours of release, there appeared to be enough fresh water in Akjemguiga Cove for the fry to imprint.

The 91 pink salmon fry collected and preserved from this project were examined by staff of the FRED Division Pathology Section. Samples were taken from the (1) transport tank prior to release, (2) the above-falls trap, (3) the below-falls intertidal trap, and (4) the holding box below the falls.

Of all the fry examined from above the falls, 75% had a cephalic bump, and 98% had an exophthalmic condition ("popeye"). Thirty-four percent of the fry from below the falls had a cephalic bump and 56% had "popeye". The pink salmon fry were apparently subjected to a hyperbaric condition prior to release into the Paint River. The FRED Division Pathology Section reported that of the 41 fry taken from the transport tank, all had "popeye" and 7 fry in 10 had the cephalic bump (Appendix D). The cause of the problem is presently under investigation and could be related to supersaturated water during transport.

Another pink salmon fry-stocking project was conducted in the Paint River during May 1983; 502,000 emergent fry from the Tutka Lagoon Hatchery were transported to the Kamishak Bay area by helicopter. The fry were not marked for this release. This project was conducted to determine various aspects of fry stocking to the Paint River system; e.g., downstream outmigration mortality as well as imprinting efficiency. It was the fourth stocking of the Paint River since 1980 (*see* Table 5).

After several weeks of waiting for suitable flying weather, the Paint River pink salmon fry were transported on 27 May. The transport tank was filled with 568 liters of water, and the 502,000 pink salmon fry (0.23 g) were piped into it. The oxygen bottle, fitted with a medical regulator, was turned on to allow a flow of 13 liters per minute. The flight lasted approximately 90 minutes; during that time the tank-water temperature increased from 4.0° to 5.5°C. The ambient stream water was 6.0°C. Fry were released in a side channel, approximately 10 km upstream from the falls area. The selection of a side channel for these releases was important because it would allow the fry to recover from the transport stress in the slower moving water and to acclimate to the temperature differential.

1983 Stream Residence and Over-Falls Mortality Testing

Pink salmon fry were released approximately 10 km upstream from the Paint River Falls at 1300 hours on 27 May. The above-falls trap was checked at 1530 hours and no pink salmon fry were found. The below-falls intertidal fry trap was checked at 1630 hours and five pink and one chum salmon fry were found; all appeared to be in good condition. The first fry was trapped approximately 3 hours after release; this was similar to the previous year's study.

The following day both traps were checked, and only the intertidal trap contained fish: 47 pink and one chum salmon fry. Twenty-five pink and the one chum salmon fry were placed in a 5% formalin solution for later examination. The remainder of the fry were then released. Strong winds and heavy rains caused the river level to rise over 1 m, destroying both traps before they could be safely removed. Further fry sampling was impossible because of severe flooding conditions.

1983 Aerial Transport Pathology Study

Data were collected in the 1983 transport to find and correct the cause of the "popeye" and cephalic-bump conditions observed in the 1982 fry transport.

Total Dissolved Gasses (TDG):

The levels of gas saturation that the pink salmon fry experienced in transit are shown in Table 7.

Gross Observations:

The appearance of pronounced cephalic bumps was noticed 27 minutes following departure from the hatchery. At 45 minutes into the flight, cephalic bumps were still present on the heads of the fish, but they were not pronounced. At this time the amount of feces in the water container had increased noticeably. At 58 minutes into the flight cephalic bumps were still present on the fry, but they were not pronounced. Cephalic-bump conditions of fry at 1 hour and 8 minutes and at 1 hour and 21 minutes were similar to the observations made at 58 minutes.

Microscopic Examination:

Brains. Fish sampled at the end of the flight had ventricular fluids in the brain that were slightly more vacuolated than those sampled prior to the flight. The ventricles also contained less fluid at the end of the flight and appeared to have decreased in volume. The size of the brains appeared to be slightly larger at the end of the flight (possibly from the influx of ventricular

Table 7. Total dissolved gasses in transport water during 1983 aerial transport pathology study.

Altitude (m)	Time (minutes)	TDG (%)
150	1	101.48
335	4	103.37
400	3	104.48
425	6	106.12
460	3	106.78
520	7	107.02
550	8	106.90
580	20	107.68
610	20	107.42
670	3	108.91
700	4	108.54

fluids). The space between the surface of the brain and the neurocranium was decreased for fish sampled at the end of the flight.

Eyes. Exophthalmos was not observed in fish during the flight; it was first detected in the fish that were collected after they had been released.

Air bladders. A slight increase in air-bladder volume was detected in fish sampled immediately following departure from the hatchery; thereafter, air-bladder samples decreased slightly in volume but were still larger than the controls. The air bladders of fish collected after the release had noticeably decreased in volume. This may have been partially caused by poor formalin fixation. During the flight, the air-bladder wall increased in hyaline appearance, underwent breakage, and became hemorrhagic (Appendix E).

Pink Salmon Adult Return Evaluation

The evaluation of the returning adults was important because the number of marked fish (Paint River) recovered in the falls area or other areas, such as Tutka Lagoon, would indicate whether the released fry had enough time to imprint to their new release site (Table 8). The holding patterns of schools of returning adults in the falls area would also help determine the best location of the proposed steep-pass. An important observation would be whether or not the adults would spawn below the falls, since they originated from an intertidal spawning stock.

1981 Return:

On 28 July approximately 600 pink salmon were sighted off the mouth of Paint River by a commercial fish spotter. Subsequently, an ADF&G biologist joined the crew of the seining vessel Key Maid to collect samples. Moving across the tidal flats in front of

Table 8. Paint River pink salmon adult return summary, Kamishak Bay, 1981-1982.

Release year	Number released	Return year	Adult returns	Survival (%)
1980	554,000	1981	25-600 a/	0.10
1981	509,000	1982	4,700 b/	0.92
1982	405,000	1983	0 c/	0
1983	502,000	1984	d/	

a/ Only one verified mark was recovered in Kamishak Bay. Several sightings of fish homing back to the falls have varied between 25 and 600. Survival is estimated at 0.10%.

b/ Aerial surveys conducted by Commercial Fisheries Division suggest at least 2,400 adult pink salmon returning and staging in the intertidal area below the falls. An additional 300 pink salmon were harvested by commercial seiners. Another 2,000 pink salmon were observed at the nearby McNeil River system. Since there have never been any pink salmon returns to that system, these fish were attributed to the Paint River release. Total run accountability was estimated at 4,700 fish or 0.92% survival.

c/ No adults returned. 1981 brood year fry were from the last 5% of the emerging fry at the hatchery and were considered in very poor condition because of delays caused by poor weather conditions.

d/ Based on survival rates ranging from 0.1 to 1.0%, the adult return could range between 500-5,000 fish.

the mouth of the river, the vessel scattered a school of 40-50 salmon that were unidentifiable because of poor visibility.

Simultaneously, the Key Maid's spotting plane was looking for the large school of pink salmon that had been sighted 4 hours earlier; however, the pilot observed only about 20 to 25 pink salmon off the mouth of the river. The biologist attempted to reach these fish in a seine skiff but was prevented from doing so by an ebbing tide. Unfortunately, because of the extreme depth of the water within the canyon-falls area, the pilot could not locate the fish, and none were collected during this operation.

On 31 July personnel from FRED Division and CIAA transported a rubber raft, motor, and gill net to the mouth of the Paint River by helicopter; however, after extensive aerial surveys over the flats, the mouth, and canyon-falls area, no fish were located. The gill net was then stretched across the river mouth on an incoming tide; simultaneously, an extensive boat survey was made within the canyon walls to the base of the falls; again, no fish were located. Water depth was more than 16 m in this area. Another aerial survey was conducted without success. The gill net was finally pulled at low tide; the only fish caught was one small Dolly Varden. After leaving the river by helicopter, about 15-20 pink salmon were sighted moving up the channel in the flats.

The adult return resulting from the 1980 pink salmon fry stocking of the Paint River was considered minimal. Only two Paint River marks (AdLV) were recovered in the lower Cook Inlet seine fishery. One mark was recovered by a commercial seine fisherman off of Amakdedori Beach, approximately 6.2 km north of the Paint River. Although fish were screened during the entire Tutka Bay return, only one AdLV mark was recovered there.

Not enough marks were recovered to estimate the return to Paint River, but with the visual estimates ranging from 25 to 600 returning adults (0.1% survival), it seems the transplant was not successful. Possible reasons for this may have been failure of the fry to imprint or over-the-falls mortality.

1982 Return:

An estimated total of 4,700 adult pink salmon returned to the Paint River system. Approximately 300 were harvested by Kamishak area commercial seiners. On 17 August another 2,400 fish were observed in the area below the gravel sill of the intertidal falls; these fish were spawning in the gravel substrate in the extensive intertidal flats. An additional 2,000 were observed orienting to the McNeil River system, which has never had pink salmon returns. Ocean survival was calculated at 0.92%. Although this is higher than 1981's return (0.10%), it is still not as high as we had hoped for. However, this figure nearly achieves FRED Division's rule-of-thumb acceptable level for direct hatchery releases (1.0%).

Two beach-seining attempts in the shallow intertidal area resulted in the collection of 105 adult pink salmon. Only one marked (AdLV) male pink salmon was found. It weighed approximately 2.5 kg and measured approximately 500 mm.

The area of intertidal-spawning activity at Paint River appeared similar to that of the Tutka Creek area (Tutka Bay Hatchery, Kachemak Bay), which was downstream from the fry-trap location at the confluence of Tutka Creek and the lagoon channel; similar salinities and freshwater lens effects could also be expected. Because these pink salmon originated from Tutka broodstock, the returns to Paint River may be successful in spawning intertidally. To measure the success of the spawners, preemergent fry sampling was planned the following spring.

Underwater observations were conducted from the proposed primary fishpass location (Figure 8, #1) to the intertidal gravel-sill

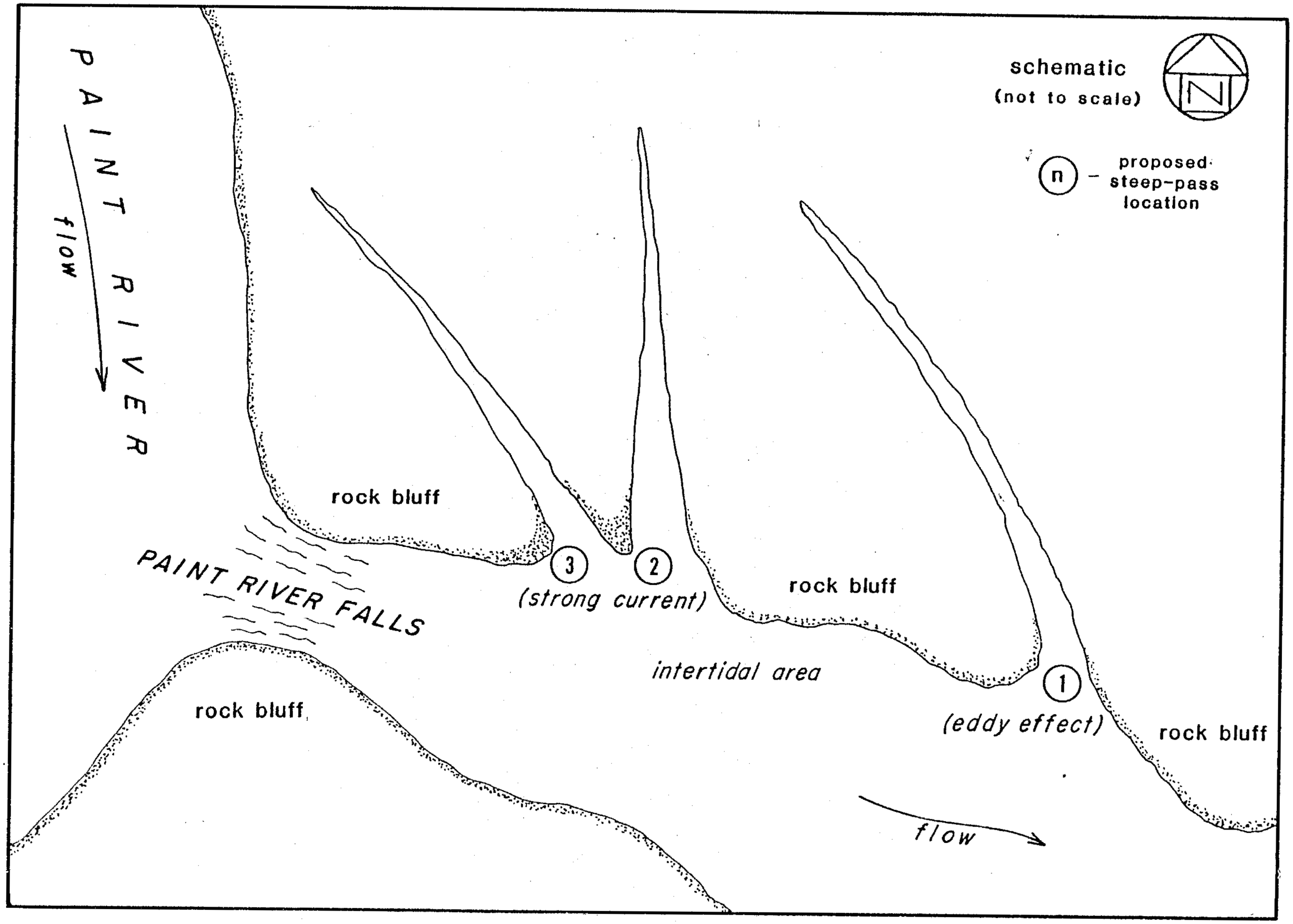

Figure 8. Schematic of Paint River Falls and proposed fishpass locations, (numbered circles) Kamishak Bay.

area in the river canyon. The survey was accomplished with skin-diving equipment during a flood tide. About 200 adult pink salmon were observed orienting to the eddy at the base of the potential steep-pass site. A small school of Dolly Varden and a second school of about 50 pink salmon adults were also observed in the eddy. This information reinforces our theory that adults will school and hold in the resting area of this natural eddy. We think they will be easily attracted to a fishpass built at that location. The incoming tide mixing with the fresh water created a visibility problem, and it was impossible to survey any of the other portions of the canyon because of strong currents.

1983 Return:

No adult salmon were observed returning to the mouth of the Paint River from the 1982 release of over 400,000 pink salmon fry. This is not surprising as these fry were of poor quality. Because of a late break-up and very poor weather during the spring of 1982, the transport had to be postponed several times. Suitable weather finally prevailed in mid-June; however, the only fry available at that time were from the last 5% of the emerging fry at the hatchery and in poor condition because of a lengthy holding period.

1984 Return:

During an aerial survey of the mouth of Paint River, over 2,500 adult pink salmon were observed spawning in the intertidal gravel. Of the 5,200 pink salmon stocked in May 1983, the "best guess" survival rate was from 0.5% to 1.0%.

Adult Return Summary

Although low numbers of adults have been thus far produced, the fry-stocking program at Paint River should still be considered a potential method of brood-stock development. Alternative methods of adult transport and/or eyed-egg planting operations in the Paint River should be investigated and pursued. Although in-stream survival of fry would be lower than for transplanted hatchery fish, higher marine-survival rates might be realized because of higher imprinting potential.

The use of mainly freshwater spawners is an important criterion for future pink salmon brood-stock selection. In 1982 nearly all the returning pink salmon spawned in the intertidal-shelf area after they had encountered the falls. The Tutka Creek brood stock was composed primarily of intertidal spawners. When the fishpass is built, the majority of the returning pink salmon adults should readily move into the river system.

Engineering Surveys

On 18 June 1980 an engineer (George Cunningham) and biologist (Alan Quimby) from FRED Division and a biologist (Tom Mears) from CIAA conducted a survey of the Paint River system. The purpose of the survey was to observe the intertidal falls at low and high tide and to determine a feasible plan to provide a fishpass over the Paint Lake Falls just below Lower Paint Lake. Thermographs were also checked and replaced in the system.

June 1980 Intertidal Falls Survey:

The intertidal falls at the mouth was surveyed at a +0.2-m (0.7 ft) low tide. Orienting downstream (*see* Figure 8), the strongest current appears to be along the north bank; there is a clockwise eddy at the base of fishpass site #1. This strong current could pose a problem with adult fish returning to fishpass sites #2 and #3. If the fish move up the estuary on the north side or on the south side and move across to the north side through the strong current, it is possible that they would not move back to fishpass site #1. This speculation can be confirmed by further observations. The current is dispersed near the entrance of fishpass site #1, with quiet water moving in a counter-clockwise motion (Figure 8). If necessary, there is also a large underwater shelf at the entrance to the site that could serve to support a lead across the estuary to direct the fish to the fishpass. Subject to the concerns of strong currents, a weighted seine net could be set up on a pulley system and pulled across the estuary, like an underwater curtain.

Depending upon the movements of the fish, fishpass site #1 appears to be the most favorable site. It would require more rock work to get the fish to an area above the falls; however, the entrance would provide easier access for the fish than at the other two sites. A beach that will provide easy access to the construction site is located near the falls. A landing craft could be brought into the bay on high tides and off-loaded on this beach.

At the time of this survey, the river appeared to be running about 15 to 20 cm higher than normal; it was crystal clear and the water temperature was 9°C. Later that evening at high tide (4.7 m [15.4 feet]), the falls were checked again; there was essentially no difference in the main current or eddies described above.

June 1980 Paint River Lake Falls Survey:

A survey of Paint Lake Falls revealed an old stream channel that could be brushed out and cleaned up to provide a natural passage around the falls (Figure 9). Some minor rock work at the head of the channel would be required to lead the water into the existing course. About three pieces of 3-m fishpass sections would be installed in the upper reaches of the channel to traverse the steeper grade. Small concrete cofferdams in the lower reaches would provide resting pools. The level river bottom and calmer water at the downstream end of the island would provide a good

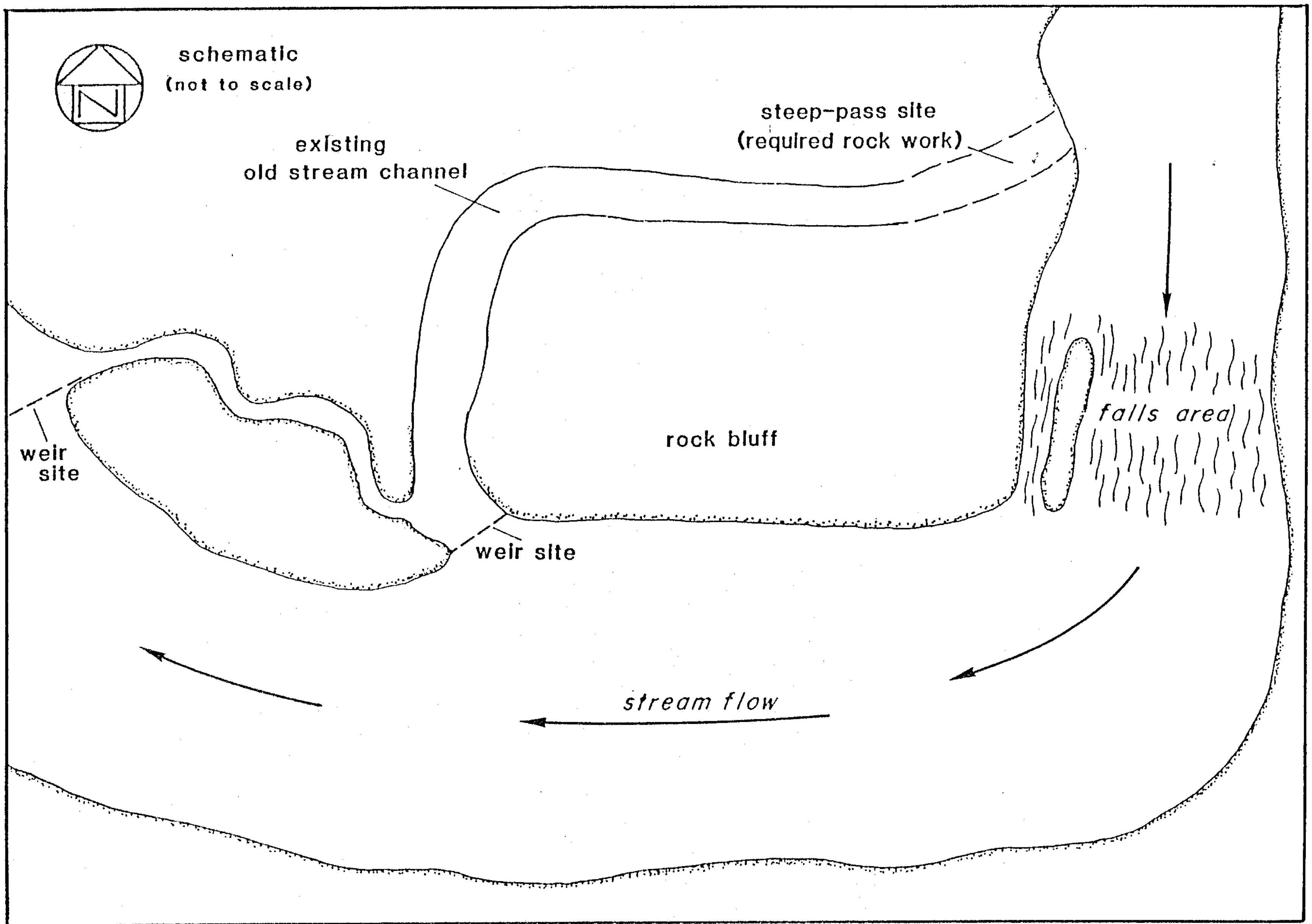

Figure 9. Schematic of Paint Lake Falls and potential fish passage site, Kamishak Bay.

area to install a weir to lead the fish into a side channel that, in turn, would lead them into the fishpass. A small weir at the upstream end of the island would prevent the fish from missing the fishpass entrance.

September 1981 Survey:

This survey was conducted as a follow-up to the June 1980 survey. FRED engineers arrived on 18 September 1981 to survey the Paint River Falls area. The engineers established three major reference points (survey grades and elevations) for the potential primary fishpass and an alternate site. Soundings were made in the pool below the falls. At low tide the water had a minimal depth of 13 m. At the highest tides of the year, the water depth would be about 15 m. A natural eddy on the right-hand side of the pool should lead the salmon to the primary site for the fishpass. The minimal depth in that eddy was 11 m at low tide; that is a sufficient depth for fish to stage before moving up the fishpass. Aerial photographs were also taken at the end of the survey. Because of snow and adverse weather conditions, the Paint Lake Falls survey was cancelled.

Engineering Designs and Cost Estimates

FRED engineers submitted four alternative plans for the fishpass construction. Of these plans, the engineers favored the tunneled steeppass alternative over the fish silo and other open-cut channels. The available documents for each plan are shown in Appendix F. The three open-cut channels follow the same alignment and are identical for the first 73 m. All alternatives are vertical-slot type fishpasses.

Alternative #1:

This fishpass would begin at the low-water surface near the left bank on a line perpendicular to the river flow and parallel to the falls at the three farthest upstream points and then run parallel to the river near the brush line for approximately 73 m to the fourth fault line; this is the section common to all open-cut channels. From this point the alignment would turn approximately 60° and follow the fault to the intertidal area.

This alternative could be constructed in two ways: first, by starting at the farthest upstream point and running the rock channel at a constant grade to the intertidal area or, second, by running the common channel at a flatter grade to the fourth fault where the channel alignment would be oriented to accommodate a switchback to maintain a grade of 7.5% from there to the intertidal area. Both configurations require cuts up to 7 m deep and the removal of a larger volume of rock than any of the other alternatives. The other disadvantages to this alignment are the high annual maintenance associated with the deep rock cuts and, because the fault acts as an outlet for flood flows, the remote possibility of the structure drowning out during high flows. For these reasons, this alternative was judged not feasible. No detailed cost estimate was made.

Alternative #2:

This design uses the common channel running at a shallow grade to the fourth fault. After intersecting the fault, the alignment turns right 60° and follows along the downstream wall of the fault at 7.5% slope until intersecting with the vertical-slot spiral silo. This channel section (from the fault to the silo) would be expensive because it would involve a "sidehill" cut requiring approximately 38 m^3 of concrete for the channel-bottom slab and one wall on the upstream side.

In addition to the larger volume of concrete required, Alternative #2 would also require approximately the same volume of rock excavation. Also, the alignment would be in danger of drowning out during high runoff, but annual maintenance should be less than that of Alternative #1. No detailed cost estimate was made.

Alternative #3:

This design also uses the common channel to the intersection of the fourth fault, but from there the alignment continues at a constant 7.5% slope, entering the silo on the bank or downstream side. This configuration, while requiring approximately the same quantity of rock excavation as Alternative #1 and #2, limits the rock cut to 3.0-3.7 m depths, and the amount of concrete required would be less than in the other alternatives.

The 1983 construction-cost estimate is approximately $1.6 million. If contractor overhead and profit and Alaska Department of Transportation/Public Facilities (ADOT/PF) fees are included, the cost is approximately $2.6 million. Design cost by ADF&G is estimated at an additional $150,000.00, including detailed surveys.

Alternative #4:

This tunnel fishpass would begin in the same location as the other alignments, but it would make a long underground reversed-S curve that opens on to the intertidal area, directly across the fault on the upstream face from the fish pick-up point of the other three alternatives. Since this alternative is a tunnel, it would require less rock excavation and twice as many weir panels as the other alignments. Half of the weirs in the other alternatives would be integral parts of the silo and, therefore, included in the silo costs.

Construction cost in 1983 for this alternative would be approximately $1.3 million. Total cost, including contractor profit and overhead and ADOT/PF fees, would be approximately $2.1 million. This estimate also does not include any ADF&G design and survey costs, which would be about $150,000.00.

River Gauging Station

During the summer of 1983, the United States Geological Survey (USGS) was asked to install and operate a stream-gauging station near the mouth of the Paint River. The instruments first started recording data on 20 July 1983. High flows of 320 m^3/s[1] (11,300 cfs) were recorded for 29 November 1983 (Appendix G). On 26 November the flow was 14.4 m^3/s (507 cfs). Lows in the 2.8-3.4 m^3/s (100-120 cfs) range were recorded for February. Although the tunnel-fishpass option is thought to be capable of functioning under such changes, flow rates and their effects on the stream bed should be monitored.

Facility Support Design

The remote nature of the area and the characteristically bad weather make type and location of support facilities important. These facilities should include a bunkhouse, elevated food cache, generator and storage sheds, radio-antenna system, helicopter landing zone, float-plane and barge-landing areas, fuel-storage depots, and all-terrain vehicle road. Figure 10 presents the proposed location of these facilities.

Land Status

According to the Alaska Department of Natural Resources (ADNR), Division of Lands, the area of the Paint River mouth and drainage

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[1] For comparison, the Susitna River mean flows are as follows: at Gold Creek, 273 m^3/s (9,653 cfs); at Talkeetna, 667 m^3/s (23,570 cfs).

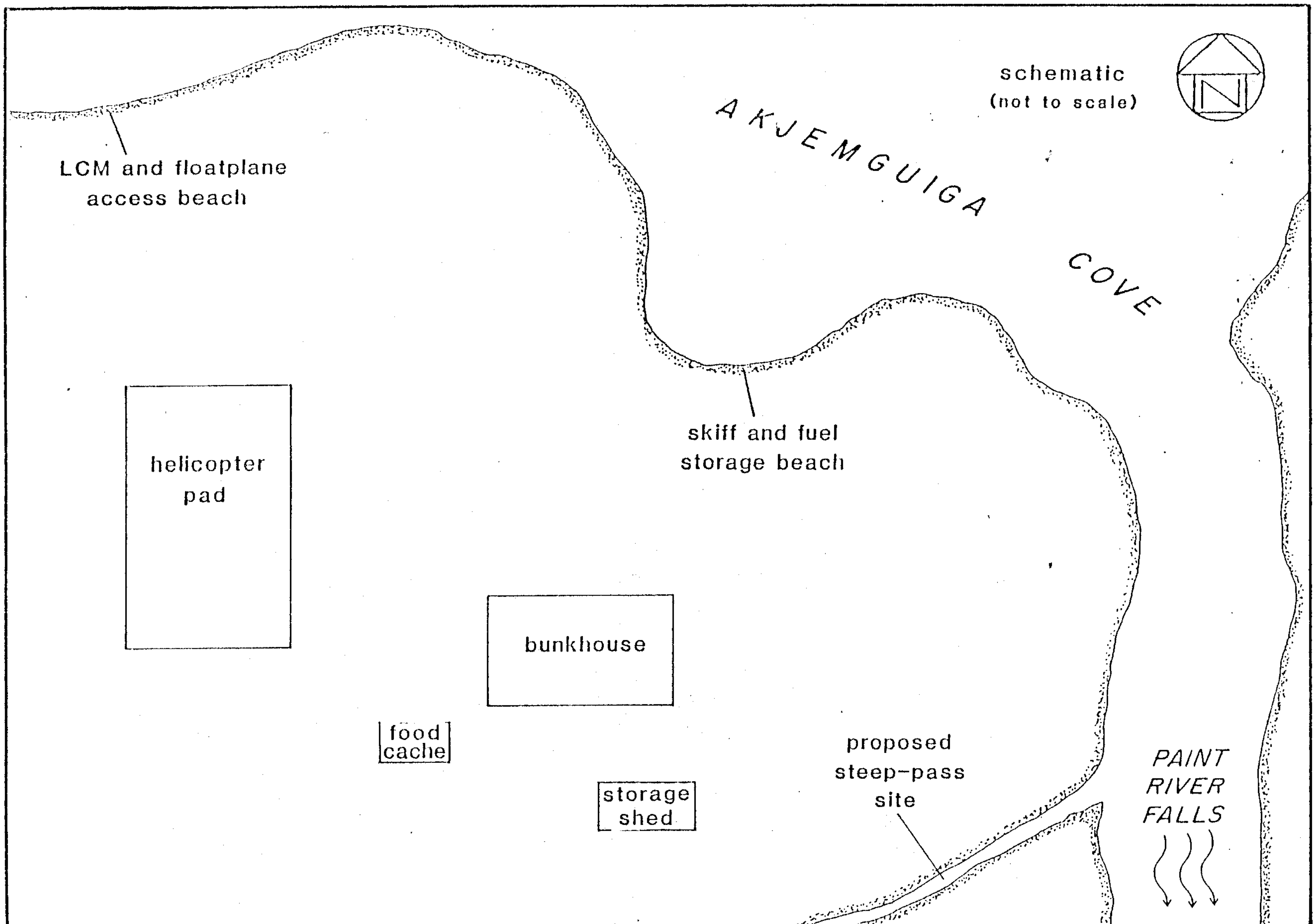

Figure 10. Proposed Paint River steep-pass facility support structures, Kamishak Bay.

is owned by the state, but it is subject to acquisition under the authority of the Alaska Native Claims Settlement Act (ANCSA). It appears that there was a noncompetitive oil and gas lease applied for on 1 December 1965 and terminated on 19 October 1971. The land was originally under the jurisdiction of the United States Bureau of Land Management (BLM). To ascertain the current status of this site, more research will be required.

Summary and Recommendations

Production Goals:

1. The ultimate annual production goals of the Paint River System, as outlined by the Cook Inlet Regional Planning Team (1982), include 100,000 adult sockeye salmon, 900,000 adult pink salmon, and 600,000 adult chum salmon.

2. If successful, this project would significantly increase salmon production in the lower Cook Inlet commercial seine fishery.

Physical Characteristics and Logistical Considerations:

1. Observations of the Paint River made during extreme winter ice and spring flood conditions indicated that this system is not susceptible to any more adverse conditions than other nearby salmon-producing streams such as the McNeil River. However, anchor-ice conditions, scouring, and winter high and low flows suggest that more information should be collected.

2. Pilot Knob River, North Fork River, and Kenty Creek, all tributaries of the Paint River, do not have suitable spawning areas for salmon. These tributaries have a series of steep falls, large boulder-strewn areas, and fast-water chutes that would make it difficult for salmon to migrate to/or spawn.

3. The main Paint River system, from the lake falls to the intertidal falls, provides excellent spawning substrate. Year-round adequate water flows, and no siltation or glacial effect have been observed. Approximately 40 km of spawning stream are available.

4. Because of the remoteness of the Paint River area and limited fixed-wing landing areas, helicopters should be considered the primary method of access.

5. Because of the limited range of the aircraft and distances involved, all helicopter trips to the Paint River require fuel to be available at the site.

6. Future aerial surveys should be scheduled more frequently during periods of extreme weather conditions. This would allow for visual interpretation of the Paint River stream and lake conditions during heavy ice, drought, or extreme flooding. Additionally at those times, it would prove valuable to continue to compare this system to other nearby salmon-producing streams.

Thermograph Monitoring:

1. Average water temperatures for September through December 1978 were 7.5°C, 2.9°C, 0.0°C and 0.0°C, respectively. Average water temperatures for June through August 1980 were 5.8°C, 8.3°C, and 9.6°C, respectively.

2. Thermograph data have been intermittent; we need to acquire more temperature data throughout the year.

3. Thermographs have been mechanically overhauled to provide more reliable service.

Limnological/Biological Surveys:

1. In June 1979 observations made in Upper and Lower Paint lakes showed no stratification of dissolved oxygen or temperature; rather, a gradual decline of each was associated with depth.

   The potential productivity of the lakes, based on conductivity and total alkalinity, appears to be identical. Compared to Chenik, Hidden, and Karluk lakes, these lakes are low on the productivity scale; but compared to Delight, Desire, and Eshamy lakes, they are high. (Appendix A).

2. Both Paint lakes have relatively low plankton densities, compared to plankton levels in Chenik Lake and Leisure Lake collected in the same time period (June 1979). This may be attributed to the cooler water temperatures encountered at the higher elevations of the Paint lakes system. Low plankton levels were found in the estuaries near the Paint River mouth. Low water temperatures also contributed to these low plankton densities.

3. The predominant species of fishes found in the Paint Lake systems were grayling, whitefish, and lake trout. Rainbow trout were identified in the lower reaches of the Paint River. Spawning substrate for salmonids is excellent in the river system and fair to good in the lake systems.

4. Seasonal plankton data should be obtained to provide comparisons with previous data from the Paint River and other systems. To document salmon fry nursery conditions, plankton data should be obtained from Akjemguiga Cove and adjacent estuarine areas.

5. Scheduled water-quality samples from the Paint Lake systems should be provided to the FRED Division Limnology Section to provide a baseline for potential fertilization programs.

6. More detailed fishery studies of the river system and its lakes should be conducted. Little information is currently available concerning potential predation and competition.

Experimental Fry Stocking and Sampling:

1. The pink salmon fry-stocking programs at the Paint River have resulted in relatively low survivals (0.0%-0.9%).

2. The feasibility of this method of brood-stock development (using hatchery fry) should be further evaluated.

3. Continued and increased effort should be considered for the fry-transport feasibility studies:

   a. to determine extent of mortality, if any, of fry emigrating through the steep intertidal falls area;

   b. to determine effects from physical injury to fry and from potential dissolved gas supersaturation resulting in Gas Bubble Disease (GBD);

   c. to determine extent of fry residency time within the stream and estuary; and

   d. to document Kamishak Bay estuarine conditions at time of fry release.

4. Further over-the-falls mortality tests should be conducted. Fry samples should also be taken before and directly following the fry transport. Testing goals would be (1) to investigate any atmospheric pressure changes during

transport resulting in supersaturation; (2) to investigate stress of transport; and (3) to recommend any needed modifications of procedures.

Aerial Transport Pathology Study:

1. The Total Dissolved Gas (TDG) levels reached during transport resulted in stressful conditions that temporarily altered brain tissues and traumatized the air-bladder wall. The appearance of "popeye" following the flight may have been the result of the supersaturated conditions, because this lesion normally appears after such conditions have been present. Transported fry should recover from "popeye" (this was the observation in the decrease in "popeye" incidence after release in 1982). The breakage of gas bladders is an abnormaltey not usually associated with GBD. The fry would not be expected to recover from it as rapidly as they would from "popeye." Survival of the released fry would be lessened if this problem occurred.

Recommendations:

1. Aeration and water temperatures, which increased 1° to 2°C during evaluation flights, need to be stabilized. Supersaturation will increase approximately 2.5% per 1°C rise in temperature (applicable only at the temperatures experienced during this study).

2. Flights at altitudes no higher than 305 m should keep the mean TDG levels at approximately 104% of saturation.

3. Changes in flight altitudes should be done very gradually to allow fish to adjust to pressure changes so that damage to air bladder and other tissues will be minimized.

4. Fish need to be held in portable raceways or pens at streamside for a period of up to 24 hours after transport. Within this period, equilibration of the TDG levels will occur. Immediate release following transport to the river and subsequent passage over the Paint River Falls will compound the stress to the fry.

Engineering Surveys:

1. The spiral vertical-slot fishpass concept appears to be the most promising, but because of the large quantity of rock excavation required at this site, it would be monetarily infeasible to incorporate the silo into the fishpass. The tunnel fishpass (Alternative #4) appears to be the most suitable plan for this remote fishpass site. Cost of this alternative design is estimated at approximately $2.1 million.

Broodstock Development:

1. For Paint River broodstock development, we recommend evaluation of existing stocks on the west side of Cook Inlet. Bruin Bay, which is located approximately 24 km by air north of the mouth of the Paint River, has been suggested as a prime source for pink and chum salmon.

2. Future brood-stock selection for pink and chum salmon should focus on freshwater spawners. In 1982 it was noted that nearly all the returning pink salmon spawned in the inter-tidal shelf area after they had encountered the falls migrational barrier. The Tutka Creek brood stock was composed primarily of intertidal spawners. When the fishpass is constructed and operational, it will be necessary for the majority of the returning pink salmon adults to move into the Paint River system.

ACKNOWLEDGMENTS

The authors would like to thank the Tutka Hatchery staff for their help in providing the labor and pink salmon fry for the helicopter transports to the Paint River. Commercial Fisheries Division was very helpful in flying aerial surveys for us when we were unable to be in the area and contacting fishermen in the area to help us with ground surveys. We greatly appreciate CIAA for their joint effort in the project. Kent Hauck provided the pink salmon fry air-transport study sections, while George Cunningham supplied the engineering analysis sections and appendices. Sid Morgan and Ken Leon provided valuable editorial comments.

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APPENDIX A

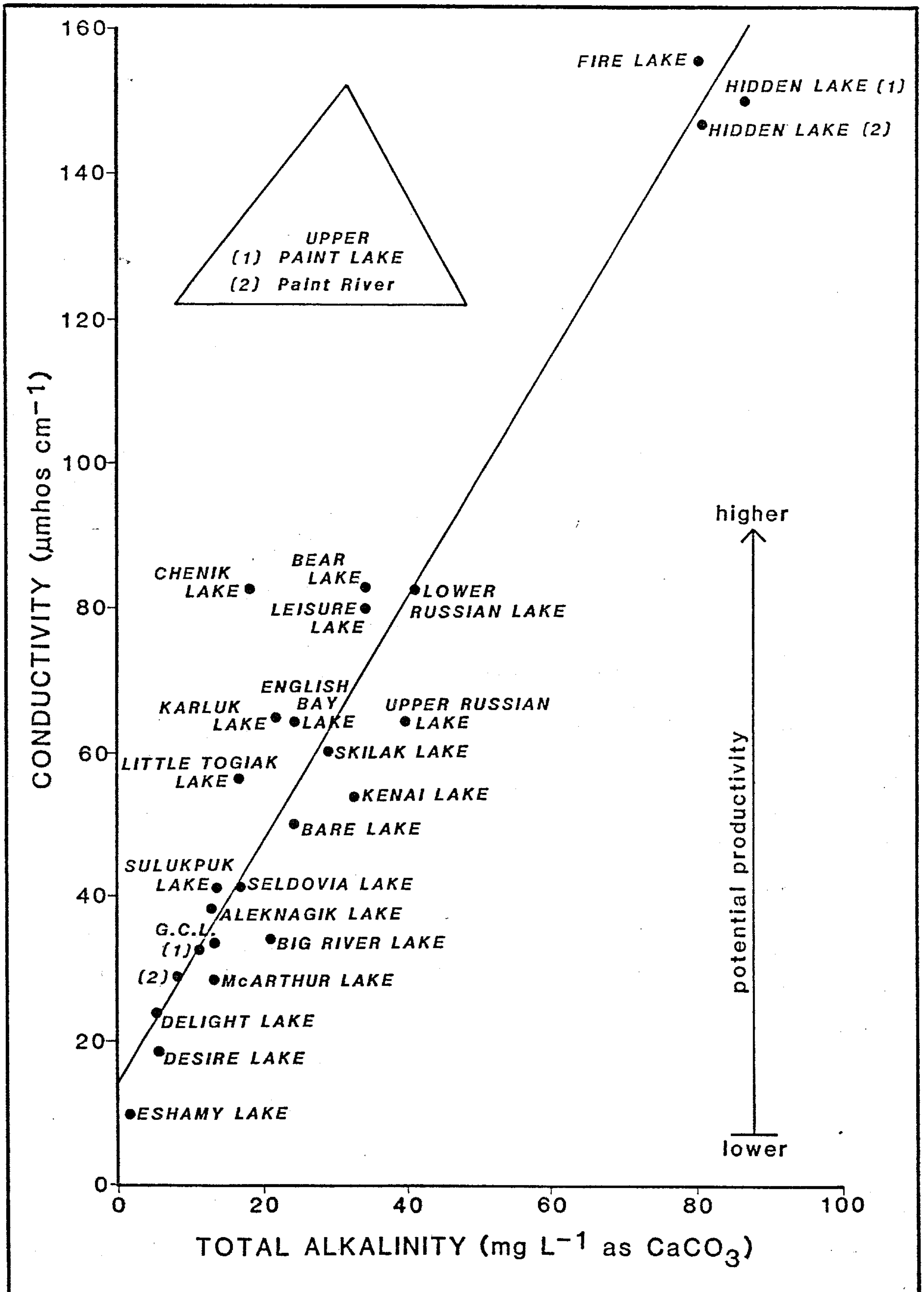


Figure A-1. A ranking of several Alaskan and Canadian Lakes as to their potential productivity or fertility towards producing salmonid food.

APPENDIX B

Table B-1. Stream survey of Kamishak District - Bruin Bay.

Date	Number fish bays	Species	Number fish streams	Species	Weather	Remarks
07/24/58			30,000	pink		head stream
			10,000	chum		
			3,000 - 4,000	pink		upper stream
07/11/60			good showing	chum		at falls
07/18/60	300		18,000	pink		head stream
			600	chum		
07/30/60			10,000	pink		head stream
07/06/61			0		rain	stream clear, bay murky
07/11/61			100	chum	clear	good vis
07/14/61			1,500 - 2,000	chum		
07/18/61			50	chum		
07/06/62			0			upper right & left
			3,500	pink		head stream
07/14/62			1,300	chum	good	head stream
			500 - 600	chum		upper stream
07/28/62			300,000 - 500,000	pink	clear	"never saw so many fish", head stream
07/28/62			5,000	pink	clear	upper right
08/01/62			6,500	pink		upper left
07/29/63			25,000	pink	CAVU	good vis
			5,000 - 6,000	chum		
08/10/63			20,000	pink	CAVU	difficult vis
07/27/64			back with fish, cannot estimate	pink	CAVU	

- continued -

Table B-1. Continued.

Date	Number fish bays	Species	Number fish streams	Species	Weather	Remarks
07/24/66	300	pink				near head end
07/28/66	500	pink	14,000	pink	windy	head end
08/01/66			15,000	pink		head end
08/25/66			5,300	pink	clear	head end
07/11/67			500	pink	calm	
07/31/68						reports of exceptional escapement on pink
07/22/69	300	pink				at mouth
08/11/69			5,000	pink		
07/14/70			300	pink		total of all stream
08/03/70			7,500	pink		
08/12/70			40,000	pink		
07/07/71			0		clear, calm	
07/15/71			20	red	clear, wind bad	3 bears, 2 moose, head stream
07/21/71						
07/28/71			1,500	pink		4 bears, head stream
08/09/71			2,400	pink		head stream
08/16/71			4,000	pink	overcast, calm	head stream
			2,000	pink & chum		right stream
09/03/71			15,000	pink	overcast, calm	head stream
07/19/72			150	pink	overcast, calm	
07/22/72			200	pink		
07/26/72			2,350	pink	clear, wind	
08/03/72			2,500	pink & chum	overcast, calm	
08/17/72			200	chum	clear, wind	head stream
			10	red		right stream
			700	chum		

- continued -

Table B-1. Continued.

Date	Number fish bays	Species	Number fish streams	Species	Weather	Remarks
07/14/73			1,400	chum	overcast, wind	head stream
07/17/73			2,500	chum	overcast, calm	
07/24/73			1,000+	chum		head stream
08/06/73			200	chum		2 bears
			1,000	pink		
08/16/73			5,150	chum		
			2,000	pink		
08/29/73			260	pink	clear, calm	head stream, many carcasses
			1,133	chum		
07/10/74			10	pink	clear, wind	
07/16/74			50	chum		
07/23/74			1,200	chum		head stream
			400	pink		
			20	chum		right stream
07/30/74			3,000	chum	overcast, calm	
08/13/74			800	chum	clear, wind	poor survey
09/06/74			100	red	clear, wind	
07/01/75	0		0		clear	air
07/10/75	100	pink & chum	0		clear	air
07/18/75	150	chum	550	chum	clear	air
07/28/75			1,000	chum	clear	air
			14,000	pink	clear	air
08/04/75			50	red	overcast	air
			1,200	chum	overcast	air
			23,300	pink	overcast	air
07/12/76	0		380	chum	overcast, wind	in lower section
			6	king	overcast, wind	in lower section
07/22/76	15	chum	2,625	chum	overcast, calm	est 3,500 to 4,000 chum in stream
			3	king	overcast, calm	some pink
08/02/76			2,000	chum	clear, wind	est 400 chum and 12,000 pink
			7,500	pink	clear, wind	est 400 chum and 12,000 pink
08/11/76			6,100	pink	overcast, calm	est 12,000 to 15,000 pink

- continued -

Table B-1. Continued.

Date	Number fish bays	Species	Number fish streams	Species	Weather	Remarks
06/21/77	0		0		clear, calm	vis exc, air
07/01/77			3	king	clear, wind	vis exc, air
			1	red	clear, wind	vis exc, air
			70	chum	clear, wind	vis exc, air
07/08/77			20	king	clear, wind	vis good, air
			600	chum	clear, wind	vis good, air
07/14/77			4	king	clear, wind	vis exc, air
			6	red	clear, wind	vis exc, air
			3,650	chum	clear, wind	vis exc, air
07/21/77			200	red	overcast, calm	
			20	king	overcast, calm	
			11,700	chum	overcast, calm	
07/28/77						lots of chum; water too muddy to count
08/16/77			22,200 stream	chum	overcast, wind	vis poor, air, est 55,000 to 60,000 pink
			15,000	chum	overcast, wind	vis poor, air, est 55,000 to 60,000 pink
06/16/78	0		0			
06/29/78	0		0			
07/08/78	0		150	chum	overcast, wind	vis poor, air
07/10/78	0		300	chum	overcast, wind	vis poor, air
07/14/78			2,100	chum		
			25	red	clear, calm	vis exc; est 3,000 in river
07/24/78			4,000	chum		
			2,000	pink	overcast, calm	vis fair, air
08/01/78			2,700	chum	clear, wind	vis exc, air
			21,300	pink	clear, wind	vis exc, air
			150	red	clear, wind	vis exc, air
08/09/78			23,500	pink	clear, calm	est 30,000 to 35,000 in river
08/18/78			23,900	pink	clear, wind	vis good, air.
			500	chum	clear, wind	vis good, air.

- continued -

Table B-1. Continued.

Date	Number fish bays	Species	Number fish streams	Species	Weather	Remarks
06/18/79	0		1	king	overcast, calm	vis fair, air
			30	red		
07/09/79			900	chum	overcast, calm	vis fair, air
07/13/79			1,775	chum	clear, calm	vis exc, air
			400	pink		
07/18/79			6,000	chum	clear, wind	vis exc, air
			300	pink		
			100	red		
07/26/79			15,775	pink		90% pink
07/30/79			50,000	pink	clear, wind	vis exc, air
			15,000	chum		
08/03/79	23,000	pink	122,000	pink	clear, wind	vis exc, air
			20,000	chum		
08/17/79			93,000	pink	overcast, wind	est 150,000 to 200,000
08/22/79			67,800	pink	clear, calm	vis exc
07/03/80	0		75	chum	overcast, wind	air
07/07/80	0		165	chum	overcast, wind	vis poor, air
			15	pink		
07/14/80			TOO WINDY			
07/16/80			5,100	pink & chum	clear, calm	vis exc, air
07/19/80	13,000	pink	14,950	chum	clear, calm	vis exc, air
07/23/80	5,000	pink	33,700	pink & chum	clear, wind	air, est 50% pink
			300	red		
07/26/85			45,900	pink & chum		air, est 10% chum
07/28/80	lots		118,000	pink & chum		air, est 10%-15% chum, vis fair
08/04/80	10,000	pink	255,000	pink	clear, calm	vis exc, air
08/12/80			255,000	pink		vis good, air
08/19/80			270,000	pink		air, est 350-400,000 total escapement

- continued -

Table B-1. Continued.

Date	Number fish bays	Species	Number fish streams	Species	Weather	Remarks
06/19/81	0		0			air
06/22/81			7	chum	overcast, wind	vis poor, air
			35	pink		
06/25/85			7	king		air
			60	pink		
06/29/81	100	chum	100	chum	overcast, wind	vis poor, air
			50	pink		
07/07/81			20	king	overcast, wind	air
			1,400	chum		
			700	pink		
07/11/81	3,100	chum	2,100	chum	overcast, calm	vis fair, air
			1,300	pink		
07/18/81			12,300	chum	overcast, calm	vis fair, air
			2,000	pink		
07/23/81			600	channel	overcast, wind	vis poor, air
			5,000	pothole		
07/25/81			13,100		overcast, wind	vis poor, air
07/29/81			15,400	chum	overcast, wind	vis poor, air
			5,000	pink		
07/31/81	5,000		500	red	clear, calm	vis good, air
	5,900	pothole	45,700			
08/03/81	300		8,100	chum		
	4,500	pothole	43,000	pink & chum		air
08/12/81			91,500	pink	clear, calm	air, 5,000 in pothole
08/18/81	350	bay	98,700			
	2,800	pothole				

APPENDIX C

FISH PATHOLOGY SECTION
FISHERIES REHABILITATION ENHANCEMENT AND DEVELOPMENT DIVISION
ALASKA DEPARTMENT OF FISH AND GAME
333 RASPBERRY ROAD
ANCHORAGE, ALASKA 99502
Phone 267:2244

FISH HEALTH RECORD

Report Date: 6/14/83
Accession Number: 830358
Contact Person (receives original report): Alan J. Quimbv
Contact Person Address: P.O. Box 234
Homer, Alaska 99603
Number of Copies: 3
Copies to: 3.19, MAR
Facility Location: n/a
Facility Name: Sport Fish
Sample Site: Bruin Bay
Sample Date: 4-7-83
Number in Sample: 30
Sample Type: Whole Fish
Brood Year: Wild
Brood Source: Bruin Bay
Species: Oncorhyncus keta
Life Stage: Fry
State: Dead/ Frozen
Percent Mortality/Time: n/a
Date of Outbreak: n/a
Clinical Signs: n/a

Service Requested
- Bacterial Culture:
- Fluorescent Antibody Technique: BKD
- Histopathology:
- Parasitology:
- Virology:
- Water Quality:
- Other:

Reason for Sample: Broodstock screen

Dissolved Oxygen (mg/1):
Temperature (°C):
Water Exchanges/hr:
NH_3 (mg/1):
Pond Cleaning Frequency:
Food Brand and Type:
Feeding Rate:
Most Recent Therapy and Date:
Recent Stressors:
Date Received: 6-6-83
Date Completed: 6/13/83

Accession Number: 830358

Fluórescent Antibody Technique:
Conjugate: Anti-KD
Findings and Incidence: 0/58 BKD positive

Comments/Recommendations: These fish are most likely suitable as a brood source.

Investigators and Initials
Microbiologist: Follett, Hopkins
Fish Pathologist:
Fish Health Inspector: Hauck

FISH PATHOLOGY SECTION
FISHERIES REHABILITATION ENHANCEMENT AND DEVELOPMENT DIVISION
ALASKA DEPARTMENT OF FISH AND GAME
333 RASPBERRY ROAD
ANCHORAGE, ALASKA 99502
Phone 267:2244

FISH HEALTH RECORD

Report Date: 6/14/83
Accession Number: 830359
Contact Person (receives original report): Alan J. Quimby
Contact Person Address: P.O. Box 234
Homer, Alaska 99603
Number of Copies: 3
Copies to: 3.19, MAR
Facility Location: n/a
Facility Name: Sport Fish
Sample Site: Bruin Bay
Sample Date: 4-7-83
Number in Sample: 30
Sample Type: Whole Fish
Brood Year: Wild
Brood Source: Bruin Bay
Species: Oncorhyncus gorbuscha
Life Stage: Fry
State: Dead/Frozen
Percent Mortality/Time: n/a
Date of Outbreak: n/a
Clinical Signs: n/a

Service Requested
- Bacterial Culture:
- Fluorescent Antibody Technique: BKD
- Histopathology:
- Parasitology:
- Virology:
- Water Quality:
- Other:

Reason for Sample: Broodstock evaluation

Dissolved Oxygen (mg/1):
Temperature (°C):
Water Exchanges/hr:
NH_3 (mg/1):
Pond Cleaning Frequency:
Food Brand and Type:
Feeding Rate:
Most Recent Therapy and Date:
Recent Stressors:

Date Received: 6/6/83
Date Completed: 6/13/83

Accession Number: 830359

Fluorescent Antibody Technique:
Conjugate: Anti-KD
Findings and Incidence: 0/55 BKD (Renibacterium salmoninarum) positive

Comments/Recommendations: This stock is most likely suitable as a brood source.

Investigators and Initials
Microbiologist: Follett, Hopkins
Fish Pathologist: Hauck
Fish Health Inspector:

APPENDIX D

Fish Pathology Section
Fisheries Rehabilitation Enhancement and Development Division
Alaska Department of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99502
Telephone: 267-2248

FISH HEALTH RECORD

Report Date: 12/6/82
Accession Number: 83-0128 (amended report)
Contact Person (receives original report): Al Quimby
Contact Person Address: P.O. Box 234, Homer, AK 99603
Number of Copies: 4
Copies to: Hauser, MAR, 6.4.20, 6.8.3
Facility Name: Tutka Hatchery
Sample Date: July, '82
Sample Site: Paint River
Number in Sample: 91
Sample type: whole fish
Brood Year: 1981
Brood Source: Tutka Lagoon
Species: pink salmon (Oncorhynchus gorbuscha)
Life Stage: fry
State: fixed in 10% formol saline
Service Requested: necropsy
Reason for Sample: To examine Tutka Lagoon pink salmon after release in Paint River for signs & lesions (emphysema, gas embolisms) resulting from supersaturated water which may exist below the falls.

Date Received: August, '82
Date Completed: 11/22/82

Comments/Recommendations: See original report (83-0128) for reference.

In a phone call on 12/2/82 from Alan Quimby, it was learned that the 41 live fry, which were initially reported as from the "upstream holding" above the falls, were actually taken directly from the holding tank before release into the river. This information would indicate that the signs/lesions reported as cephalic bump and popeye occurred either prior to transport from the hatchery or due to altitude changes during the transport flight.

Gas supersaturated water in the holding tank is not considered the cause since popeye lesions are seldom seen in fish from water with or below moderate (110%) total dissolved gas (TDG) levels. Also, gas emboli and emphysema, often the first lesions seen with moderate supersaturation levels, were not visible in the gills or fins. The possibility that the 41 fish survived from acute gas levels (approximately 120% TDG), which can occur without the formation of typical signs/lesions, is also remote. If gas levels were at the 120% level, the fish would likely have not survived the combined supersaturation and transport stresses.

Accession Number: 83-0128

Regardless of the cause, the incidence of lesions was lower for downstream than for upstream (above the falls) fish. This may reflect a reversal of those signs/lesions to the normal state. In any case, the stress accompanying those signs/lesions may later facilitate the development of conditions or infections which may impact the survival of the fry.

According to Al Quimby (phone conversation 12/2/82), some popeye was observed in these fish at the hatchery before transport. The popeye and cephalic bump lesions, which were moderate (not pronounced) in all fry samples involved with this report, were not seen in fish examined during this year's prerelease inspection (4/22/82; 82-0174).

I recommend that this stock be more thoroughly examined before and during next year's transport to eliminate pathogens as the cause and to shed more light on the situation.

Investigators and Initials

Microbiologist:

Fish Pathologist: A. K. Hauck *AK*

Fish Health Inspector:

APPENDIX E

Fish Pathology Section
Fisheries Rehabilitation Enhancement and Development Division
Alaska Department of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99502
Telephone: 267-2248

FISH HEALTH RECORD

Report Date: July 25, 1983
Accession Number: 83-0360
Contact Person (receives original report): Nick Dudiak
Contact Person Address: Homer
Copies to: 3.19, MAR, 6.7.0, 6.8.0, 6.4.20, Burkett, Grischkowsky, Hauser, Kaill, Leon, Quimby, Rosenbalm, Sullivan
Sample Date: 5/30/83
Sample Site: Tutka Hatchery & Paint River
Number in Sample: 80
Sample Type: whole fish
Brood Year: 1982
Brood Source: Tutka
Species: pink salmon, *Oncorhynchus gorbuscha*
Life Stage: fry
State: live
Percent Mortality/Time: none at time of release

Service Requested:
- Necropsy
- Histopathology
- Water Quality

Reason for Sample: to test water during fry transport for supersaturated conditions and to examine fry for their reactions to the transport conditions.

Date Received: 5/30/83
Date Completed: 7/25/83

Methods and Materials:

Flight data: A tank containing approximately 0.55 million pink salmon fry in 300 gallons of aerated hatchery water was flown suspended below a Bell 212 helicopter from the hatchery to Paint River on 5/30/83. The duration of the flight was 1 hour and 22 minutes. Maximum flight altitude was 2300 feet. Changes in altitude were made as slowly as conditions would permit, and total dissolved gas (TDG) readings were taken at varying altitudes during the flight to allow for adequate equilibration of equipment and to result in optimum readings. Because the helicopter was not equipped for flying with the tensionometer probes suspended inside the transport tank, a separate 5 gallon container holding hatchery water was carried within the aircraft for water testing purposes.

Accession: 83-0360

Water and atmosphere testing: Two tensionometers (Common Sensing, Inc.) and one Weiss saturometer were used to measure supersaturated conditions. The saturometer was used at the hatchery prior to the flight as a means of assuring the accuracy of the tensionometer readings. The tensionometers were used before, during, and after the flight in recording simultaneous readings. This was done in the event one machine did not equilibrate quickly or function properly during the flight. During the return flight, one tensionometer was used to obtain atmospheric pressure data. The calculation of TDG levels was done following the method of Nebeker et al., 1976. Both the TDG and barometric pressure readings were regressed linearly against altitude using the Hewlett Packard 97 Standard Pac Curve Fit Program.

Specimen examination: In order to facilitate fry sampling and visual observation of the fry reactions to the transport conditions, a container holding live fry was carried within the aircraft. During the flight, live fish were checked periodically for changes in behavior and in anatomy. Five samples of fish were taken during the experiment: 1) normal (control) fish from the hatchery prior to the flight; 2) experimental fish at the beginning of the flight at an altitude of 2000 feet; 3) experimental fish at the end of the flight before descent; 4) experimental fish at the end of the flight after descent; 5) after release of the fish into Paint River and their subsequent capture in fry traps. Samples numbered 1-4 were placed live into Bouin's fixative. Those fry captured after release were fixed at the streamside in 10% formol saline. This solution was changed to 10 neutral buffered formalin following receipt of the sample at the laboratory. Standard histopathological techniques were used for the five fish samples.

Results:

Water and atmosphere testing: Atmospheric pressure readings were found to decrease with increase in altitude, as expected. The following data were obtained statistically for these relationships:

$$r^2 = 0.76$$
$$a = 744.04$$
$$b = -0.02$$
$$y = -744.04 + 0.02x$$

The average for TDG readings was 106.65% for all measurements from take-off to arrival, with a range of 101.31% to 109.41%. The TDG readings increased with increase in altitude and resulted in the following statistical data:

$$r^2 = 0.89$$
$$a = 99.87$$
$$b = 3.96\text{x}10^{-3}$$
$$y = 99.87 + 3.96\text{x}10^{-3}$$

Accession: 83-0360

The length of flight time spent at the various altitudes and mean TDG levels were as follows:

Altitude (feet)	Time (minutes)	TDG (%)
500	1	101.48
1100	4	103.37
1300	3	104.48
1400	6	106.12
1500	3	106.78
1700	7	107.02
1800	8	106.90
1900	20	107.68
2000	20	107.42
2200	3	108.91
2300	4	108.54

Specimen Examination

Gross observations: The appearance of pronounced cephalic bumps was noticed 27 minutes following departure from the hatchery. At 45 minutes into the flight, cephalic bumps were still present on the heads of the fish, but they were not pronounced. At this point the amount of excretia in the water container had increased significantly. At 58 minutes into the flight cephalic bumps were still seen on the fry, but they were not pronounced. Cephalic bump conditions of fry at 1 hour and 8 minutes and at 1 hour and 21 minutes were identical to the observation made at 58 minutes.

Following the flight, it was noticed that the buoyancy of the fixed fry varied significantly. All of the fry sampled at the hatchery were buoyant at the surface of the fixative. Of the fry sampled directly following departure, 4/7 (57.1%) were buoyant. Of the fry sampled directly prior to arrival at Paint River, 2/7 (28.6%) were buoyant. And none of the fry sampled following landing at Paint River were buoyant at the surface of the fixative.

Microscopic Examination:

Brains: Ventricular fluids in the brains were slightly more vacuolated in fish sampled at the end of the flight. The ventricles also contained less fluid at the end of the flight and appeared to have decreased in volume. The size of the brains appeared to be slightly larger at the end of the flight (possibly from the influx of ventricular fluids). The space between the surface of the brain and the neurocranium was decreased for fish sampled at the end of the flight.

Eyes: Exophthalmia (popeye) was not observed occurring in fish during the flight. Popeye was first detected in the fish of sample #5 which was collected after the fry had been transported and released.

Air bladders: A slight increase in air bladder volume was detected in fish sampled directly following departure from the hatchery. Air bladders of samples collected thereafter had decreased slightly in volume, but were still larger than the controls. The air bladders of fish collected following the release of the fry had decreased

Accession: 83-0360

significantly in volume. This may have been partially caused by suboptimal fixation of the sample fixed in formalin. During the flight, the air bladder wall increased in hyaline appearance, underwent breakage, and became hemorrhagic.

Discussion and Recommendations: The microscopic signs typical of gas bubble disease (tissue emphysema and embolisms) were not detected. The TDG levels reached during the transport definitely resulted in stressful transport conditions which temporarily altered brain tissues and traumatized the air bladder wall. The appearance of popeye following the flight may have been the result of the supersaturated conditions, as this lesion normally does appear a period of time after such conditions have been present. However, popeye will also become resolved after the fish have been removed from the supersaturated water and should do so also for the transported fry (this was the observation in the decrease in popeye incidence after release as reported in 1982). The breakage of gas bladders is a sign not normally seen with GBD. This lesion would probably not be resolved as rapidly as the head alterations, and would adversely affect the survival of the released fry for a longer duration as repair is underway.

Recommendations: 1) Aeration and stabilization of water temperatures (which increased 1-2° C during the flight) are necessary, as supersaturation will increase 2.5% per 1° C rise in temperature.
2) Flights at altitudes no higher than 1000 feet should keep the mean supersaturation levels at approximately 104%.
3) Changes in flight altitudes should be done very gradually to allow fish to adjust to pressure changes, eliminate stress from changes in pressure which may occur during sudden altitude changes, and to minimize damage to air bladder and other tissues.
4) Hold the fish in portable raceways at the streamside for a period of up to 24 hours after transport. Within this period equilibration of the supersaturated levels will occur. Immediate release following transport into the river and the eventual passage over the Paint River falls will compound the stress to the fry.

Nebeker, A. V., G. R. Bouck, and D. G. Stevens. 1976. Carbon dioxide and oxygen-nitrogen ratios as factors affecting salmon survival in air-supersaturated water. Trans. Amer. Fish. Society. 105(3):425-429.

Investigators and Initials:
Fish Pathologist: A. K. Hauck
Fish Health Inspector: A. K. Hauck AKH

APPENDIX F

BY........ DATE

CHKD. BY........ DATE........

SUBJECT Alternate #3 Paint River Spiral Fishway

SHEET NO. 1 OF 2

JOB NO.........

CLASS OF WORK OR MATERIAL	QUANTITY	UNIT	MATERIAL UNIT	MATERIAL EXTENSION	LABOR UNIT	LABOR EXTENSION	TOTAL x1000
Mobilization							
Homer Stagging Area	1	LS.		50000 00			
Boat Charter	20	days	3000-	60000 00			110.00
a) Equipment Rental							
Compressor 3@ 943.00	9	Mon	2829-	24451 -			
Generators 2@ 550-	9	Mon	1100-	9900 -			
Cent. Pumps 4" 2@ 1355-	9	Mon	2710-	24390 -			
Drills 3@ 487-	9	Mon	1461-	13149 -			
Hose & Fittings	9	Mon	300-	2700 -			
Loader Track	9	Mon	3321-	29889 -			
Dozer	9	Mon	3360-	30240 -			
Clam-Link Belt HC48A	5	Mon	8613-	43065 -			
Clam Shell Sq. Nose. Std.	5	Mon	985-	4925 -			
Air Track	4	Mon	7779-	31116 -			213.83
b) Camp -	1	L.S.		55000 -			
Setup & Mtls	1	L.S.		20000 -			
c) Misc.	1	L.S.		10000 -			85.00
Demob							
Boat Charter 2-5 day trips	10	days	3000-	30000-			
Clean-up & land transport	1	L.S.		15000 -			
Misc.	1	L.S.		5000 -			50.00
Material							
Explosive	300	case	100	30000 -			
Caps 100/box	40	box	75	3000 -			
Detonation Cord.	5	coil	75	375 -			

BY .... DATE ....

CHKD. BY .... DATE ....

SUBJECT Alternate #3 Paint River Spiral Fishway

SHEET NO. 2 OF 2

JOB NO. ....

CLASS OF WORK OR MATERIAL	QUANTITY	UNIT	MATERIAL UNIT	MATERIAL EXTENSION	LABOR UNIT	LABOR EXTENSION		TOTAL x1000
Drill Steel	1	L.S.		500 -				
Drill Bits	1	L.S.		2500 -				
Cement (patio mix 0.5 ft^3)	1100	bags	5.50	5940 -				
Rebar	2500	lbs	0.65	1625 -				
Weir panels	27	ea	2500-	67500 -				
Misc	1	L.S.		10500 -				121.94
Operating Cost								
Equip. Op. Cost	1	L.S.		60180 -				
Camp Op. Cost	1764	md	75	132338 -				192.52
Labor	26100	mh			30.25	789515		789.52
					Construction Cost			1562.81
					Overhead & Profit		25%	390.70
					DOT		20%	390.70
					Contingency		10%	234.42
					1983 Dollars			2578636.00

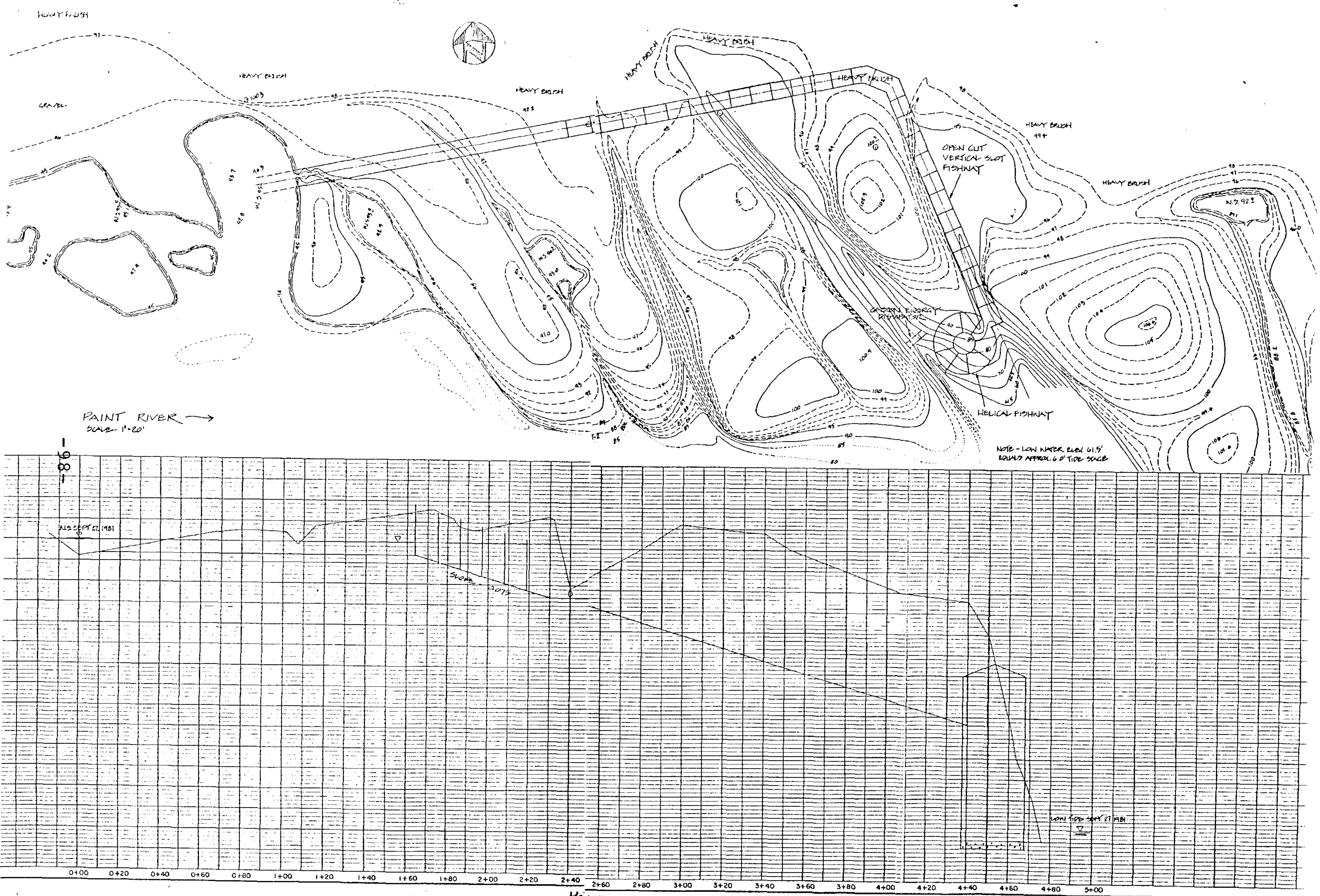
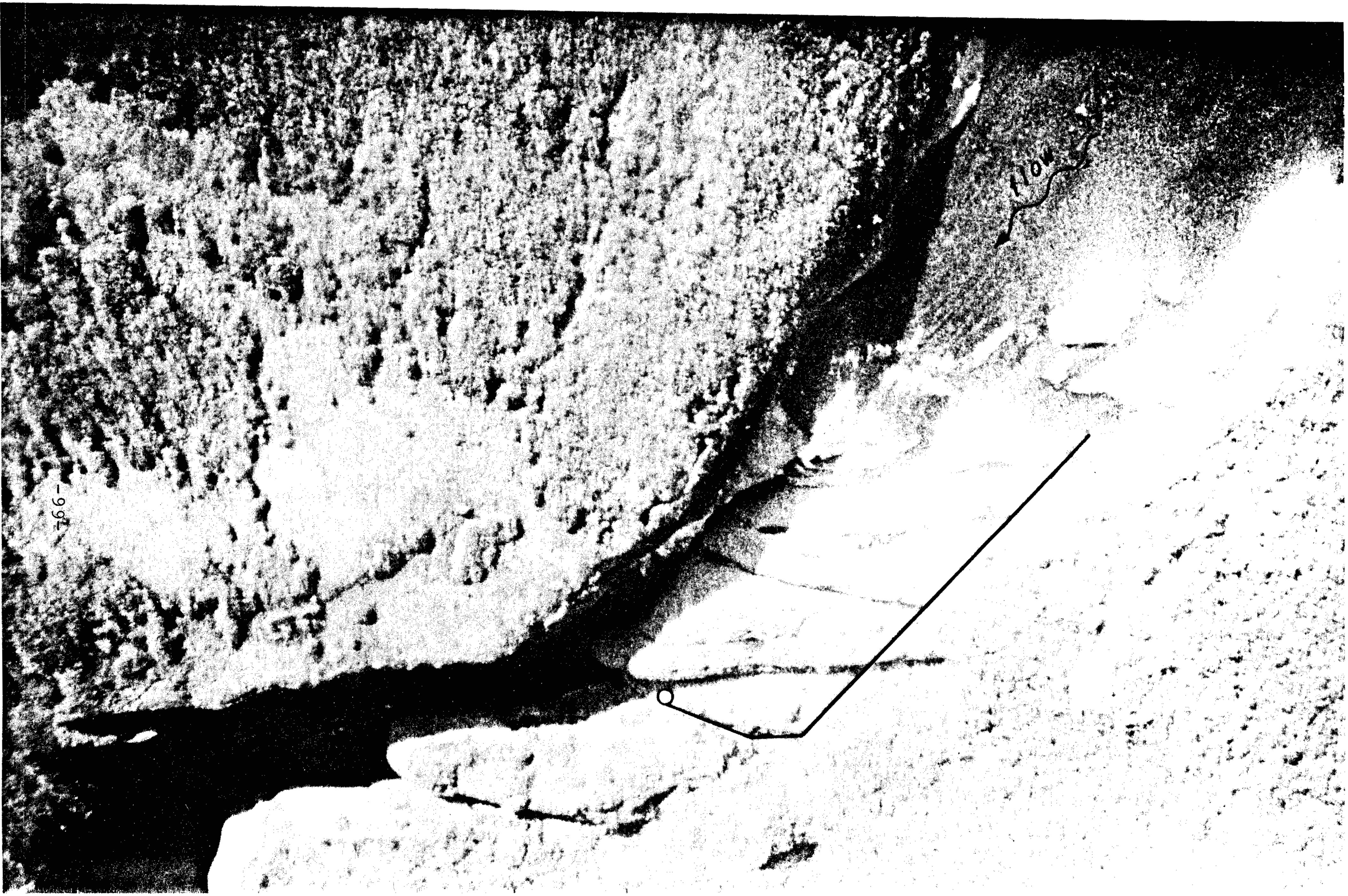


PLATE 1 PLAN PROFILE

PAINT RIVER CONCEPTS - JANUARY 1984
ALTERNATE #3 SPIRAL FISHWAY



Paint River Alternate #3 Vertical Slot Fishway & Silo

BY. .... DATE ....
CHKD. BY .... DATE ....
SUBJECT .... Alternate #4 Paint River Tunnel Fishway
SHEET NO. 1 OF 2
JOB NO. ....

CLASS OF WORK OR MATERIAL	QUANTITY	UNIT	MATERIAL UNIT	MATERIAL EXTENSION		LABOR UNIT	LABOR EXTENSION		TOTAL x1000
Mobilization									
Homer Stagging Area	1	L.S.		50000	00				
Boat Charter 4 - 5 day trips	20	days	3000-	60000	00				110.00
a) Equipment Rental									
Compressor 2 @946-	8	mon	1895-	15160	-				
Pressure Pump	8	mnth	895-	7160	-				
Axial Flow Ventailation Blower	8	mnth	192	1536	-				
Drill & Air leg 3 @487-	8	mnth	1461-	11688	-				
Crawler 65 HP Class	8	mnth	3360-	26880	-				
LHD	8	mnth	6752-	54016	-				
Generators 12 kw 2 @549	8	mnth	1100-	8800	-				
Centrif. Pump 4" 2 @1258	8	mnth	2516-	20128	-				
Hose suck/press & fittings	8	mnth	300-	2400	-				147.77
b) Camp	L.S.	1		55000	-				
Materials & setup	L.S.	1		15000	-				70.00
c) Misc.	L.S.	1		10000	-				10.00
Dembo									
Boat Charter 2-5 day trips	10	days	3000-	30000	-				
Clean-up & land transport	L.S.	1		15000	-				
Misc.	L.S.	1		5000	-				50.00
Materials									
Explosives P.F. = 10	300	case	100-	20000	-				
Caps case 100 caps	40	case	75-	3000	-				
Detention Cord	5	rolls	75-	375	-				
Drill Steel Misc. length	L.S.	1		500	-				
Drill Bits	L.S.	1		2500	-				

BY .... DATE ....

CHKD. BY .... DATE ....

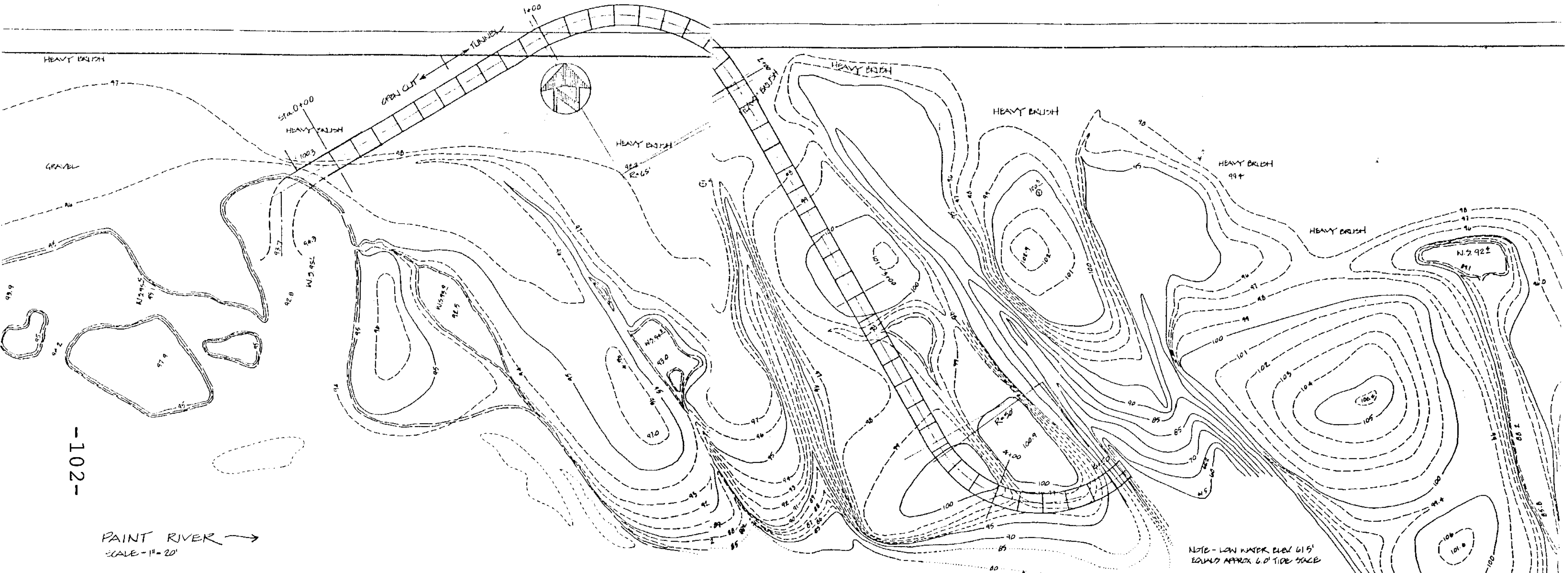
SUBJECT: Alternate #4 Paint River Tunnel Fishway

SHEET NO. 2 OF 2

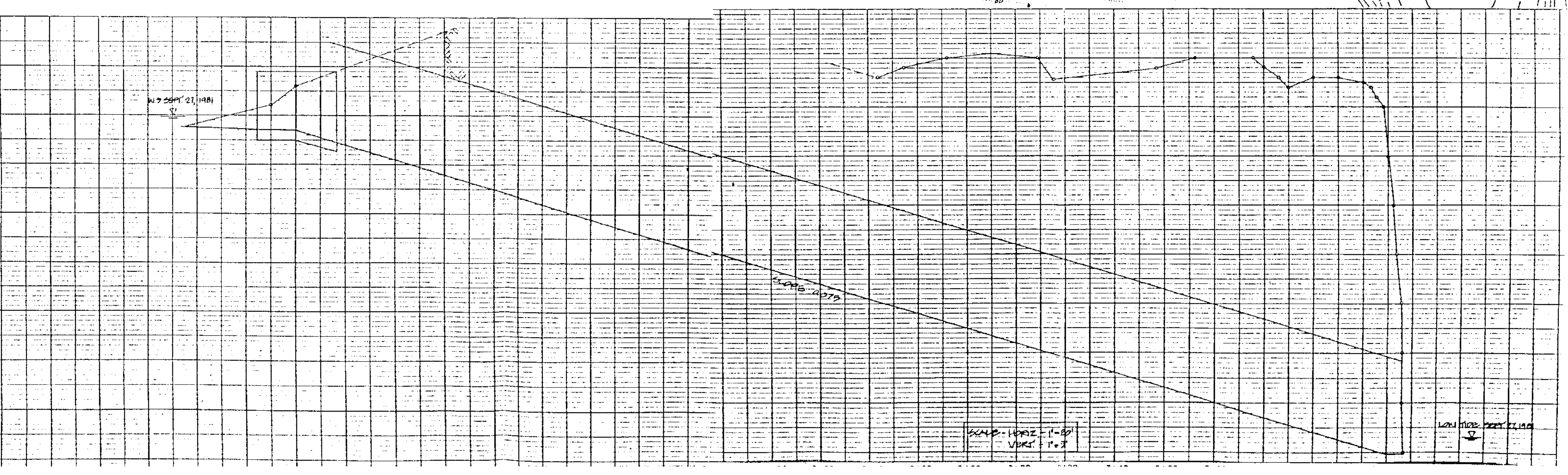
JOB NO. ....

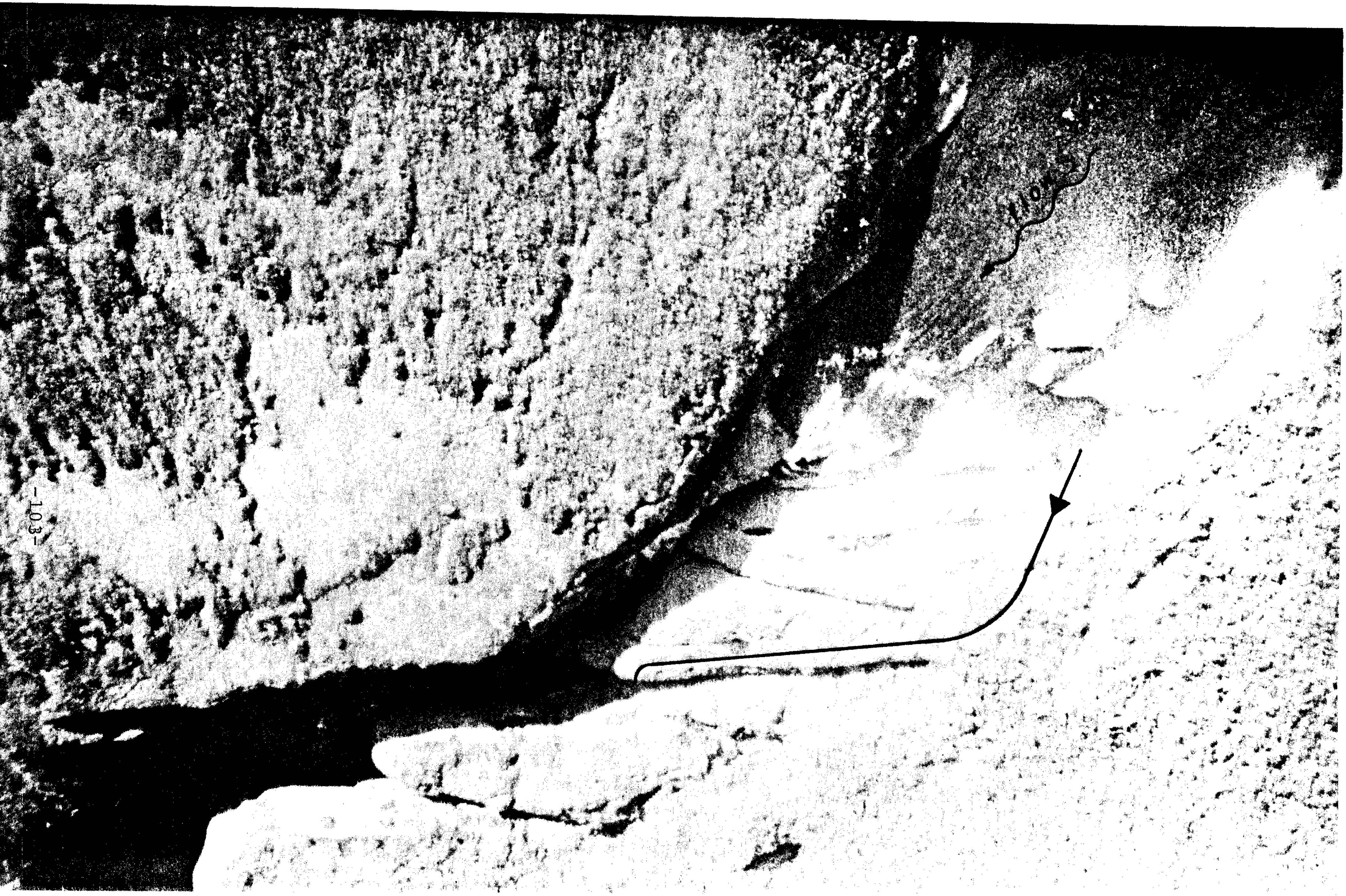
CLASS OF WORK OR MATERIAL	QUANTITY	UNIT	MATERIAL UNIT	MATERIAL EXTENSION	LABOR UNIT	LABOR EXTENSION	TOTAL x1000
Materials cont.							
Tunnel liner	24800	lbs	0.65	16120 -			
Cement Patio Mix	2100	bags	5.50	11550 -			
Rebar	3000	lbs	0.50	1500 -			
Rock Bolts	460	each	12.50	5750 -			
Weir Panels	46	each	2500	115000 -			
Pipe 3" 0	600	feet	5.60	3360 -			
Pipe 1" 0	600	feet	1.65	992 -			
Creosote Timber 3"x10'x12'	1020	l.f.	2.0	2040 -			
Misc.				10000 -			202.69
Operating Cost							
Equipment Op. Cost	L.S.	1		68135 -			
Camp Op. Cost	1429	md	75-	107175 -			
							175.33
Labor	14290	mh			36.68	524157 -	524.16
				1983 Construction Cost			1289.95
				Overhead and profit		@ 25%	322.49
				DOT		@ 20%	322.49
				Contingency		@ 10%	193.49
				Total 1983 Dollars			2128.42

-101-



PAINT RIVER →
SCALE - 1" = 20'





Paint River Alternate #4 Tunnel Fishway

APPENDIX G

PROCESS DATE: 01-MAY-85 12:43 888

15294900 ~~Caint~~ River near Kamishak, AK

DRAINAGE AREA:

LAT 590914 LONG 1541532 STATE 02 COUNTY 170 DATUM OF G:

PROVISIONAL RECORDS SUBJECT TO REVISION

PROVISIONAL DATA DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1983 SEPTEMBER 1984
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1080	546	5000	145	120	110	270	3240	2260	3470	646	351
2	2550	611	3410	145	120	110	210	2520	2750	2550	616	338
3	995	755	2040	140	110	300	200	2000	2900	2110	627	331
4	598	637	1120	140	110	1000	200	1320	3290	2240	543	323
5	559	611	742	140	110	3000	190	923	3330	2290	553	320
6	546	598	592	140	110	7500	190	718	3140	2200	425	318
7	520	1210	456	150	100	6000	190	716	2870	2160	404	314
8	507	3630	304	170	100	4000	190	885	2810	1690	394	481
9	572	3260	280	210	100	9000	180	1150	2990	1640	395	1020
10	2160	4780	255	280	100	9000	180	1490	3200	1350	400	455
11	2040	4090	240	405	100	6000	180	1790	3060	2210	596	380
12	1260	2110	220	2330	100	4000	180	1540	3250	2220	423	356
13	742	1050	210	4220	100	3200	180	1510	3980	1630	383	474
14	650	663	200	2450	100	2200	180	2070	3720	1390	363	3580
15	901	572	195	782	100	1400	180	2350	3360	1140	367	4580
16	729	546	190	355	100	1000	180	3750	3230	1110	367	2970
17	2510	520	180	242	100	700	180	5650	3220	1190	363	1750
18	2660	507	180	230	100	500	180	6400	2760	922	919	1250
19	1350	507	180	230	100	350	180	4850	2430	736	1390	995
20	874	507	200	230	100	300	180	3750	2500	534	639	789
21	2390	716	190	200	100	250	180	3450	2400	582	1300	562
22	1550	559	180	194	100	220	190	3230	2200	819	3150	555
23	901	540	180	180	100	210	180	3060	2530	1110	1550	1610
24	835	533	180	170	100	200	190	2810	4110	751	1630	4690
25	598	520	180	160	110	190	220	2690	6830	517	2140	4000
26	585	507	190	150	110	190	367	2450	5740	542	1450	2590
27	572	533	180	140	110	190	764	2400	3410	536	931	2110
28	559	5510	194	130	110	200	1510	2310	2750	470	647	2470
29	546	11300	181	130	110	210	3340	2360	2970	412	479	2910
30	533	8000	169	120	---	230	4340	2150	4570	511	383	4800
31	546	---	157	120	---	420	---	2030	---	476	363	---
TOTAL	33418	56458	18171	14823	3030	61150	15091	77652	98560	41978	24846	47672
MEAN	1078	1882	586	478	104	1974	503	2505	3285	1354	801	1589
MAX	2660	11300	5000	4220	120	9000	4340	6400	6830	3470	3150	4800
MIN	507	507	157	120	100	110	180	716	2200	412	363	314
CFSM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
IN.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AC-FT	66280	112000	36040	29410	6010	121400	29930	154000	195500	83260	49280	94560

WTR YR 1984 TOTAL 492884 MEAN 1347 MAX 11300 MIN 100 CFSM .00 IN. .00 AC-FT 977600

PROVISIONAL RECORDS SUBJECT TO REVISION

PROVISIONAL RECORDS SUBJECT TO REVISION

[illegible] River near Karishak, AK   PROCESS DATE: 01-MAY-85 15:32 TSB

LONG 1541532 STATE 02 COUNTY 170 DAT OF GAGE: DRAINAGE AREA:

PROVISIONAL DATA DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER [illegible]4 TO SEPTEMBER 1985
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	6260	1400	330	3330	2320							
2	3740	711	349	1610	1500							
3	2820	498	380	805	1000							
4	2930	456	1470	534	600							
5	2940	518	2160	493	400							
6	4110	560	1670	539	250							
7	3470	464	1110	503	---							
8	2210	290	677	919	---							
9	1650	280	490	303	---							
10	1300	270	400	1580	---							
11	1050	260	380	2200	---							
12	853	250	350	1420	---							
13	683	250	320	900	---							
14	599	300	300	666	---							
15	450	423	500	512	---							
16	438	663	424	465	---							
17	409	772	409	1100	---							
18	395	512	404	2710	---							
19	390	417	397	2450	---							
20	380	563	390	3170	---							
21	373	460	599	2550	---							
22	383	407	796	1990	---							
23	367	370	697	1570	---							
24	393	330	600	1110	---							
25	534	290	437	770	---							
26	374	250	360	919	---							
27	369	270	350	1610	---							
28	351	290	350	2550	---							
29	345	300	350	4450	---							
30	332	310	450	4670	---							
31	1070	---	523	3740	---							
TOTAL	42014	13114	18442	52538	---							
MEAN	1355	437	595	1695	---							
MAX	6260	1400	2160	4670	---							
MIN	345	250	300	465	---							
CFSM	.00	.00	.00	.00	---							
IN.	.00	.00	.00	.00	---							
AC-FT	83330	26010	36580	104200	---							

CAL YR 1984 TOTAL 458407 MEAN 1252 MAX 9000 MIN 00 CFSM .00 IN. .00 AC-FT 909300

PROVISIONAL RECORDS SUBJECT TO REVISION

PROVISIONAL RECORDS SUBJECT TO REVISION